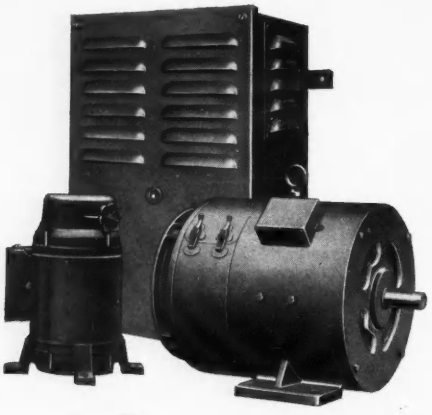
The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XIII No. 5. MAY, 1952

HE SHEFFIELD TWIST DRILL AND STEEL COMPANY LTD
HEFFIELD · ENGLAND · PHONE: 24137 (5 LINES) · GRAMS: PROELLS · SHEFFIELD
don Office: TERMINAL HOUSE · LOWER BELGRAVE STREET · S.W.1 · Phone: SLOANE 2111 (4 lines) · Grams: 'PROELLS KNIGHTS LONDON'

ormer Tools are obtainable from your usual Engineers' Merchant



THE 'PLUS' BEHIND THE FINEST ELECTRICAL EQUIPMENT

"Electro Dynamic" equipment is the outcome of years of experience. Every unit is precision-built to withstand hard, constant use . . . every piece of equipment is eminently suited to its job.
And then there is the "Electro Dynamic" 'Plus' providing for the adaptation or complete re-designing of units to match up to special requirements and a team of technicians always ready with experience and expert assistance.
Why not consult us at the drawing board stage ?

ELECTRO DYNAMIC CONSTRUCTION COMPANY LTD.

Head Office and Works: ST. MARY CRAY, KENT

Phone: ORPINGTON 2560-3

CONTROL GEAR WORKS: BRIDGWATER, SOMERSET

"Cronite" RECD. TRADE MARK

now WRITE FOR A NEW BOOKLET

The HIGH TEMPERATURE ALLOY

SALT, LEAD AND CYANIDE VESSELS
CARBURIZING BOXES AND POTS
ROTARY RETORTS & PROPELLING WORMS
FURNACE HEARTHS AND FITTINGS
ENAMELLING PERRITS AND SUPPORTS
GLASS-BLOWING NOZZLES
PYROMETER PROTECTION SHEATHS
CASTINGS FOR USE AT 700°/1200° C.

The CRONITE FOUNDRY Co. LTD.
LAWRENCE RD · TOTTENHAM · LONDON N.15
PHONE · STAMFORD HILL 4237

THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *UNGROUND BALL BEARINGS*

A so-called "unground" ball bearing is an assembly composed of precision ground and polished balls together with hardened raceways having smooth, machined surfaces. Frequently, the parts are assembled into and held together by a soft-steel outer band or form an integral part of a machine. Because the races are not ground, these bearings are purposely made with greater internal play and broader dimensional tolerances than a precision bearing. In view of these characteristics, unground bearings are mainly used in applications where load and speed conditions range from static to medium, and where the maximum in running accuracy is not required. There is no doubt that there exist sound logical reasons for the use of such unground bearings. From the engineering viewpoint, they are fundamentally suitable for a wide variety of applications in which the expensive refinements of precision bearing tolerances and highest-quality materials would be wasted. From the economic viewpoint, the initial cost of an unground bearing is but a fraction of that of a ground bearing of comparable size; also, ground shaft and housing fits are not required. In fact, there exist numerous cases, in which the employment of an unground bearing is preferable to that of a ground bearing. A typical case is that of the mounting of two standard single-row bearings on a shaft where misalignment is apt to occur. Under these conditions, the looser construction of the unground bearing will prevent it from binding as would occur with precision bearings. Another typical case is that of a bearing mounted in a position where it would be difficult to provide for hermetic sealing of the bearing. It need hardly be emphasized that small particles of dirt can cause a precision bearing to bind, while the unground bearing, having some internal looseness, will often operate satisfactorily in spite of dirt and grit.

● *APPLICATION OF ULTRASONICS TO METAL SPRAYING*

While the main range of applications of ultrasonic vibrations appears to lie in fields where a disintegrating or dispersive effect is to be attained, a recent invention proposes their employment for the purpose of consolidating sprayed metal layers. The invention referred to concerns a method of producing smooth antifriction metal coatings particularly for bearings of aircraft and automobile engines, but a special type for diesel engines has also been developed. The underlying principle of the invention consists in producing a smooth antifriction metal coating on a metallic supporting surface by spraying the molten metal in a finely divided state onto the surface while subjecting the latter to ultrasonic vibrations, the frequency of which may range from 20 to 50 kilocycles per second. The metal intended to form the coating is supplied to the spray gun in the form of a wire of lead, red copper, aluminium, or magnesium, or their alloys. Where at least two metals are simultaneously sprayed, a wire is used which has a core on one metal concentrically surrounded by at least one other metal. A core of flux may also be provided. Microscopic or colloidal flakes of graphite may also be included in the wire, so as to produce a self-lubricating sprayed coating. As it is practically impossible to wire-draw antimonated lead containing eight per cent of antimony as used for bearing bushes, the inventors propose the use of a compound wire, the body of which is of lead, either pure or combined with tin, and the core of which is of powdered antimony, either pure or mixed with copper and lead. A deoxidizing and plastifying flux may also be added.

● *ELECTRONIC IMPACT WORK HARDENING*

A recent announcement claims that electronic work-hardening of metals may become a routine process in metal working industries in the near future, thanks to the experiments now being conducted on an "electronic hammer" to be known as "statitron," also called a Van de Graaf generator after the inventor of the original device. Unlike the cyclotron, the statitron does not smash atoms, but displaces them and, thus, is capable of changing the physical properties of a piece of metal upon which the electrons are made to impinge. In the apparatus, an endless insulated belt travelling at the speed of 3,000 fpm conveys electrons up to the top of the statitron, where they are stored on the metallic dome of the device, thus building up a very large electric charge. When released by a hot filament, the accumulated charge gains speed on its downward flow through an evacuated accelerator tube. It is computed that some 60 billion electrons per second strike the metal target at the base of the tube. Their speed of travel approximates that of light, i.e., 186,000 miles per second. The electronic energy therefore

Tufnol Ltd.,

Perry Barr, Birmingham 22B,

announce that the word

TUFNOL

is their Registered Trade Mark

and the use by others of the word

TUFNOL *in connection with*

products not made from material

supplied by Tufnol Ltd., is an

infringement of the

Trade Mark Registration.

266

impinges upon the piece of metal with such a large impact that the energy is transmitted to the atoms constituting the piece of metal. Owing to the strength of the impact, actual displacement of the atoms therefore results. The apparatus does not produce radioactivity, but does produce a very dangerous radiation background of several million times the maximum intensity to which the human body may safely be exposed. Actually, these radiations consist of very hard X-rays which are capable of penetrating very heavy pieces of steel, up to 2 ft in diameter. For this reason, the apparatus is housed in a room having thick concrete walls and a lead door.

● *INTERMITTENT JET PROPULSION FOR SHIPS*

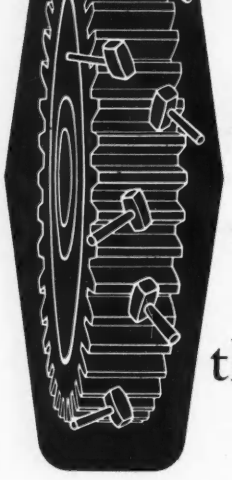
Numerous jet devices for the propulsion of marine craft have been proposed in recent years, and the pump-powered type employing water jets has actually proved its worth in special applications. Jet propulsion plant of the explosive or sudden expansion type has also been proposed, and at the present time is receiving a certain amount of attention. A recent invention envisages the creation of frequent short impulses of steam which would act as gaseous pistons. The " shots " of free vapour pistons would be expelled from orifices or nozzles into the water and thereby produce a strong propulsive effect. The use of steam for propulsion purposes by emitting periodic bursts of steam from nozzles has been applied to toy boats, but owing to the very rudimentary design of plant of this type, a negligible efficiency was obtained. The present invention aims at controlling and timing the emission of steam bursts into the water by passing the steam from the boiler into a revolving distributing valve. On its discharge side, this valve is connected with a number of pipes leading the steam to the ejection nozzles, from which the steam enters the water in short bursts. The propulsive medium need not, however, be steam, and explosion-like bursts produced by the ignition of vaporized fuels are also envisaged. In this case, timed fuel injection and ignition equipment would have to be provided. Should jet propulsion by periodic bursts directed from a number of nozzles into the water prove an attractive proposition from the aspect of efficiency, then it might be worthwhile to consider the use of free piston-type power gas generators for this purpose.

● *CORRUGATED BELLOWS MOVEMENT*

Extensible corrugated metal bellows are finding numerous applications in mechanical devices, particularly in temperature and pressure measuring devices, automatic control elements, and the like. It is well known that the extension and contraction of such bellows must be kept rather small in order to avoid premature failure by fatigue. In most cases, movement of the bellows is therefore restricted by interposing between the bellows and the indicating or recording mechanism an amplifying system which usually is of the mechanical leverage type. It has been argued that the use of an amplifying system, no matter how simple, must necessarily increase the cost of the instrument and in certain cases may adversely affect the accuracy of indication. A recent invention aims at remedying these shortcomings by the employment of a modified type of corrugated metal bellows which, it is claimed, has sufficient sensitivity to be used without the necessity of interposing an amplifying system. Another advantage claimed for the new bellows system is the considerable reduction in inertia achieved by the elimination of mechanical amplification. The invention consists in the provision of a metal strip affixed by soldering or welding along the length of the bellows. This strip prevents the bellows from extending or contracting along the line where the strip is applied, while it leaves the opposite side free to expand or contract. Deformation of the bellows under the influence of pressure or temperature, or because of the application of some extraneous force, will therefore manifest itself in an angular deviation of a pointer, or whatever motion-transmitting component may be affixed to the point of the bellows left free to move. Apparently, what remains to be seen is whether or not a deformation of this kind will result in accelerating fatigue failure owing to greater local strains.

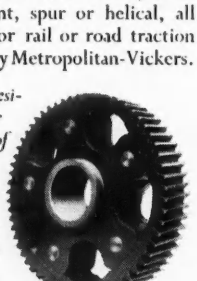
● *NOVEL STRESS RUPTURE TEST FOR TUBING*

A large percentage of high-temperature alloys is used in tubular form for heat exchangers in oil refineries and also in steam boilers. Most of the high-temperature strength data for these materials are based on tests conducted in simple tension bar specimens. The reason for this is that tubular stress-rupture or tubular creep tests have hitherto been too costly: firstly, because the tubular specimens used were too expensive, and secondly, because quite regularly the electric furnace used for heating the specimens was either damaged or destroyed when a specimen ruptured. An apparatus has now been designed in which these difficulties are largely avoided. The method consists in using tubular specimens approximating in length to 20 tube diameters, which are closed by plugs at both ends, while pressure is supplied at the top of the specimen through a connecting tube of stainless steel welded into the plug at the top and connecting with a high-pressure water reservoir. Internal volume of the specimen is reduced in order to minimize the explosive force during rupture. For this purpose, a close-fitting solid core is inserted, which takes up nearly the entire internal volume. By testing the specimen under internal pressure, actual service conditions are closely simulated, except for the external flue



Metrovick gears take the shock

The severe shock loads imposed upon gear teeth when rail points or crossings are traversed at high speeds requires their design to be far more robust than normal industrial gears. Design and manufacture of traction gears must be directly related to the design of the traction motor. Metrovick experience in the production of traction motors therefore means that M-V gears incorporate all those features arising from practical traction needs. Solid, composite or resilient, spur or helical, all types of gears for rail or road traction can be supplied by Metropolitan-Vickers.



Metrovick rubber resilient gear wheel for a tramcar. Gears of this type protect motors against impact shocks and vibration, lengthen life of motors, gear wheels and pinions, while reducing noise.

METROPOLITAN-VICKERS ELECTRICAL COMPANY LTD.,
TRAFFORD PARK, MANCHESTER, 17. *Member of the A.E.I. group of companies*

METROVICK

Gears for all Traction Drives

"airflo"

FAN POWERED VENTILATOR

EASILY FITTED TO ANY ROOF

18" FAN — STANDARD SUPPLY 400 V. 3 ph. 50~. — 3900 cfm

PRICE ON REQUEST

ALUMINIUM BODY—COMPLETELY WEATHERPROOF

Full Particulars on Request

DUST FUME AIR CONDITIONING VENTILATING PLANTS.

INDUSTRIAL FAN & HEATER COMPANY LIMITED.

EVELYN ROAD · SPARKHILL
BIRMINGHAM 11.

Telegrams: AIRFLO. **Telephone: VICTORIA 2277/8/9.**

Northern Area
22 CITY BUILDINGS, 69 CORPORATION ST., MANCHESTER 4
Telephone: BLACKFRIARS 6918

gas atmosphere and the temperature gradient through the tube existing in heat transfer service. After assembling the specimen in the testing furnace, a series of tests on the particular tube size material is started with short-time high-temperature tensile tests on duplicate specimens. This information is used to decide upon the stress and pressure levels to be used for the first few specimens with relatively short life tests. These tests furnish information for subsequent long-time tests.

● *HARDENABILITY CONTROL FOR SILICON-CHROMIUM STEEL*

A recent metallurgical investigation appears to be pointing the way to closer hardenability control and a better understanding of the reaction which occurs during the quenching of high-silicon steels. The most important finding of the investigation is to the effect that in silicon-chromium valve steel, hardenability decreases as the silicon content increases from 2·35 to 4·92 per cent. Metallographic studies established the fact that the decrease in hardenability with increasing silicon content is due to a faster critical reaction rate rather than graphitization. The higher silicon contents are conducive to ferrite formation during quenching, which is responsible for the formation of intermediate transformation products. This anomalous behaviour of silicon was definitely established by the fact that, according to the Jominy test, the lowest silicon percentage was associated with the highest hardenability. Four induction heats, in which the carbon, manganese, and residual elements were held fairly constant, were melted, the silicon percentage varying within the range of approximately 2 to 5 per cent. The austenitizing temperature required to attain complete solution was determined for each heat by oil quenching samples from a series of temperatures ranging from 1650 to 2,000° F. Metallographic examination showed the heats containing 2·35 and 3·28 per cent silicon to be completely martensitic, when quenched from 1700° F. Small quantities of ferrite persisted in the heat containing 3·97 per cent silicon until a temperature of 185° F, while ferrite persisted in the material with 4·92 per cent silicon up to a temperature of 1950° F.

● *DETECTION OF CRACKS IN PORCELAIN ENAMEL*

The cracking of porcelain enamel is a phenomenon familiar to the layman as well as to the technician engaged in fusing glass to metal. Cracks in metal-backed porcelain enamel are, however, exceedingly narrow and are generally noted only after they have received a contaminating substance. In fact, many cracks in glass and porcelain are impossible to perceive with the human eye. It is possible by experiment to show that a crack must be at least one micron in width before it becomes possible to introduce a contaminant which is visible to the eye. When a crack is less than 0·1 micron, it cannot be detected in a transparent object because no light is reflected owing to interference. In a novel patented crack detection method called the " electrified particle inspection method," a special form of calcium carbonate is blown through a composition tubing and, in passing through, rubs off electrons to the tubing. The powder, therefore, on leaving the tube, is charged positively. When this positively charged powder is applied direct to the surface of a metal-backed surface of porcelain enamel, the electrons in both the enamel and the metal tend to be attracted. The enamel, being non-conductive, will not allow its electrons much freedom to flow, except perhaps to reorientate. The metal below, however, being a conductor, will allow its electrons to flow in the direction of the positive particles which are on the surface of the enamel. The closest the electrons can get will be the glass-metal interface. If a crack exists in the enamel, the dielectric strength of the glass is much reduced at that point, and the negative potential built up in the interface will begin to leak through or influence the site of the defect on the positively charged surface. Thus, once the leakage is established, additional positively charged particles are attracted to the site of the defect and accumulate so as to provide a highly visible powder indication. It is claimed that this method allows of detecting cracks of 0·1 micron or smaller.

● *LIGHT-WEIGHT DIESEL ENGINE DESIGN*

For some time past, progress in diesel engine design has reached a stage where revolutionary advances cannot any more be expected. Diesel engine designers are, however, persisting in their efforts to improve engine weight and space requirements as well as combustion characteristics. A typical example of the approach to these problems taken in the light-weight diesel engine field is the controlled combustion process incorporated in an engine in the small power field recently put on the market. In the combustion chamber of this engine, special air cells in each cylinder receive a supply of compressed air as the piston rises towards the top dead centre position. These air cells promote complete combustion by discharging pulsations of air to improve turbulence and air-fuel mixing during the firing stroke. This contributes to a smooth sustained power impulse with reduced peak loads at end firing pressure. Three separate jets of fuel are emitted by the injector. Design and installation angles of injector and air cells cause the centre fuel stream to meet the air from the air cell at the exact centre of the combustion chamber. Three machined grooves in the crowned piston match the angles at which fuel jets are sprayed from the injector. The centre groove lines up with the middle jet from the injector nozzle. It also aligns with the air cell nozzle, so that fuel and air

ELECTROMAGNETS

LTD

The LEADING SPECIALISTS

in all types of lifting magnets and magnetic separators!

Send **YOUR** problems

to BOXMAG TRADE MARK works

BOND ST., BIRMINGHAM 19

CEN 5391. 'BOXMAG' B'HAM

COLOUR HELPS PRODUCTIVITY

"It's a big job, and it's never been painted before—"

said Grandad

Was grandad surprised when the G.H.L. men came and transformed that dirt-grimed shop into a colourful and pleasant place to work in. And another thing that surprised him was the speed and efficiency with which they went about the job. "Just no trouble at all" he said . . . and now production has been stepped up in grandad's shop.

Contractors to THE ADMIRALTY, AIR MINISTRY, MINISTRY OF WORKS, WAR OFFICE and BRITISH RAILWAYS. We shall be pleased to send you our illustrated folder, "Colour Psychology," upon request.

INDUSTRIAL PAINTING CONTRACTORS GHL

G.H.L. (PAINTERS) LTD.

DECORA WORKS, WOLVERHAMPTON ST., DUDLEY, WORCS
Phone: 4551-2-3

M-W-55

meet at the centre of this groove. The two angle grooves facilitate air-fuel mixing by providing direct paths to the outer perimeters of the " figure eight " combustion chamber. The cylinder assembly is of light-weight construction with a threaded aluminium head shrunk on a steel barrel. With a compression ratio of 14 to 1, the 125 hp engine weighs 290 lb.

● *HIGH-FREQUENCY GLUING ON SITE*

The employment of high-frequency induction heating in the woodworking industries has made great strides in recent years. The latest development in this field is claimed to be a novel portable high-frequency gluing unit which virtually spot-welds plywood panels in place within a matter of minutes. The new gluing unit was developed under the auspices of a firm of plywood manufacturers, and has successfully passed a trial period of several years. The use of a portable gluing unit is considered especially important from the economic point of view, as it has been found to permit the employment of $\frac{1}{4}$-inch plywood panelling to achieve a result which compares favourably with that previously obtainable only with more costly $\frac{3}{4}$ inch thick material. The employment of the new spot welding method completely eliminates the use of exposed surface nails, which in itself is an important advantage from the aspect of appearance and finish. Moreover, while it formerly required from four to six hours for glued panels to set, the new machine causes the glue to set almost instantaneously. A panel installation carried out with the machine is claimed to exhibit perfectly flush joints. In the conventional system of erecting plywood panelling, nails are used to hold the panels in place, while the glue is setting. When using the high-frequency electric gluing unit, " spot welds " take the place of nails, while glue in intervening areas is allowed to set naturally.

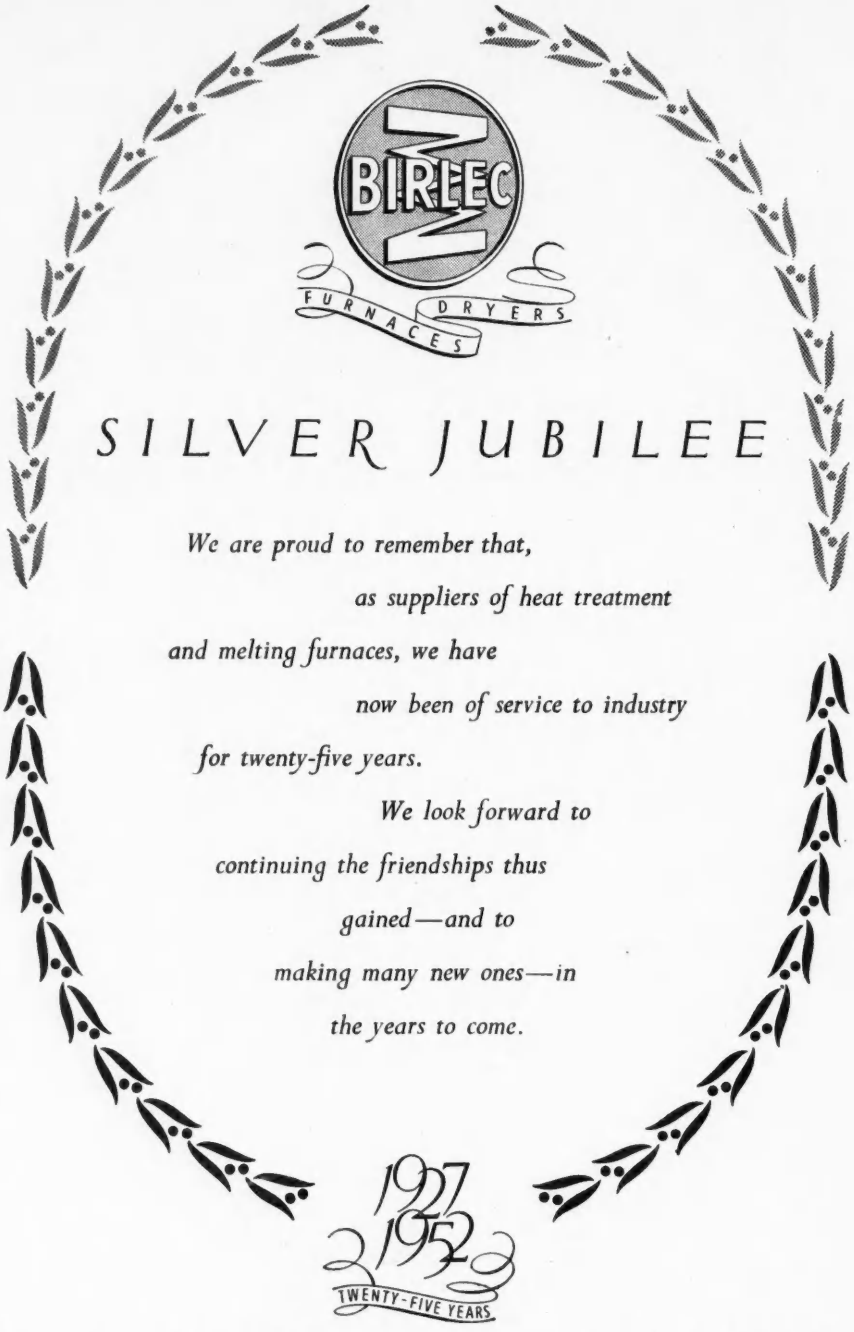
● *METAL CUTTING PROCESS*

A new chemical compound has been developed, which, in metal cutting processes, acts to limit the movements of the atoms in the crystal lattice of the metal when it is being cut. According to reports, the new process is being applied to many difficult machining operations with marked improvements in cutting-tool life. It is claimed that, in some instances of thread chasing and tapping, increases in tool life of the order of 900 per cent have been registered, while in practically all cases speeds and feeds are said to have been increased by 25 to 35 per cent. The action of the compound is likened to the physical changes occurring in steel when it is hardened by nitriding or carburizing, the most significant difference being that of the depth of penetration of the active elements, the effects of the compound being limited to approximately one molecular layer each side of the separated area. This shallow depth is due to the extremely short time available for penetration during the cutting action. The theory on which the development of the new compound is based is that the heat generated at the cutting edge per unit quantity of material removed is directly proportional to the degree of plastic deformation and the amount of metal removed per unit of time. When applying the compound to a cutting process, the compound is carried by the cutting fluid into the interspace between cutting edge and metal being in the process of removal, and embrittles the metal by the action of the nascent atoms of the compound upon the metal surface. The brittleness thus produced reduces plastic deformation during the cut and diminishes the heat generated at the cutting edge of the tool.

● *SOUND RECORDING AND REPRODUCING*

There are at present in existence two methods of recording the sound vibrations used for adding sound effects to a cinema film. One of these methods uses a sound track which has a variable luminous density on the whole width of the film, while the other method employs a sound track which has a variable width consisting of two respectively clear and dull areas, divided by an undulating line which represents the recording of the modulation of the microphone current. These two methods, which require rather intricate apparatus, enable the recorded sound vibrations to be reproduced by projecting the variations of luminous intensity upon the cathode of a photo-electric cell and employing them for modulating the anode current. A novel method of reproduction described in a recent patent is based on the fact that the current passing through a photo-electric cell, the cathode of which receives a moving spot of light, varies as a function of the point of impact of this spot of light upon the cathode. To summarize, this method relies on the use of the variation of the position of a spot of light, while the previous methods are based on the variation of the intensity of light of the flux focussed upon the cathode. When recording by this method, the electric modulation corresponding to the sound vibrations is recorded by means of a cathode-ray oscillograph upon a film or upon paper, the linear sound track produced being an undulating curve of substantially uniform thickness. The method used for reproducing sound from the recording consists in focussing upon the graph a scanning beam of light, so that on the cathode of a photo-electric cell a spot of light or a line of light interrupted by a dark spot is produced, as explained above.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.


BIRLEC
FURNACES
DRYERS
SILVER JUBILEE
We are proud to remember that,
as suppliers of heat treatment
and melting furnaces, we have
now been of service to industry
for twenty-five years.
We look forward to
continuing the friendships thus
gained—and to
making many new ones—in
the years to come.
1927
1952
TWENTY-FIVE YEARS
BIRLEC LTD · ERDINGTON · BIRMINGHAM 24

ENG
that
curr
in a
of I
for
earli
still
prob
shor
mad
beca
and
proc
ing,
" Li
rema
suffe
rang
at ev
usin
prac
syst
supp
stan
been
base
tem
merl
Asso
all I
syst
of a
num

poss
uses
med
certa
obvi
I.S.
quir
tion,

syst
coun
this
were
use
intro
the

THE ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XIII. No. 5. MAY, 1952

Standard Limits and Fits

ENGINEERS have, for some time past, recognised that the various systems for limits and fits in current use in this country (and, for that matter, in all other countries using the inch as a unit of length measurement) are totally inadequate for modern engineering requirements. The earliest of all systems, the Newall system, is still very widely used in Britain. Its popularity is probably due to its extreme simplicity, but its shortcomings are apparent from the many " tailor-made " limits which designers are forced to adopt because they cannot otherwise express the varied and stringent requirements of modern design, production and interchangeability. Broadly speaking, British Standard Specification B.S. 164 "Limits and Fits for Engineering," which remained fundamentally unchanged since 1924, suffers from the same drawback, i.e., an insufficient range of fits and restricted flexibility. Attempts at evolving new systems for limits and fits in inch-using countries to suit present-day engineering practice have been frequent, but not one of these systems has received that measure of general support which would justify its adoption as a standard. It is not surprising, therefore, that it has been decided completely to revise B.S. 164 and to base the new proposed system on the I.S.O. system (International Standards Organisation, formerly known as I.S.A., International Standards Association) which has been put into practice in all European countries using metric units; this system has proved its value and complete coverage of all engineering requirements over a great number of years.

It was recognised that an important, though possibly small, section of British industry already uses the metric system of measurement as the medium for specifying the size of some and, in certain cases, all the parts produced. It was obvious that for this section of British industry the I.S.O. metric tolerance tables would fulfil all requirements, and it is proposed that, without alteration, they should be adopted as British Standards.

The conversion of these tables into the inch system has been attempted before, both in this country and the U.S.A. Although at first sight this may appear to be an easy task, some difficulties were soon encountered owing to the necessity to use the factor 25·4 as a divisor and the consequent introduction of three-place decimals even into the tolerance ranges. For instance, whilst a tolerance range of 40-50 mm in the metric I.S.O. system looks plausible, the " literal translation " of this range into the British system, i.e., 1·575-1·969 in. (rounded off) might easily give rise to the question: Is this really necessary ? The fundamental problem is, therefore, whether to use the existing I.S.O. system merely as a theoretical basis for the development of a new tolerance system adapted to the peculiarities of the British system of measurement or whether faithfully to translate the existing metric I.S.O. system. The Technical Committee set up by the British Standards Institution has preferred the latter course, in order to obtain strict interchangeability between parts made to the I.S.O. metric system of limits and fits and to the equivalent inch system. Using the words of the Chairman, Mr. J. E. Baty, a " Chinese copy " has been produced, the inch tolerance values having been obtained, not from the I.S.O. tolerance formulae, but by direct conversion of the metric tolerance values; the tolerances thus calculated have been rounded off in order to avoid excessively precise values.

It is proposed that the symbolic notation used in the I.S.O. system for signifying a tolerance value shall be used in the inch conversion of the system without alteration. The I.S.O. system uses a letter-number combination for all tolerances, as, for example, H6, K7, M9, etc. This very clear difference between the symbols used in existing British practice and those used in the proposed system will make it unlikely for errors to occur as a result of the symbols in the I.S.O. system being confused with those in current use. The I.S.O. tables are very comprehensive and, under normal circumstances, any firm or industry would use only a small selected section of the tables. It must be emphasized that the apparent complexity of the system is due solely to its comprehensive nature, and that once an organisation has made a selection of fits to cater for its own requirements, the application of the system is extremely simple.

The letter-number combination used to denote a tolerance is made up as follows :—

A letter is used to signify the position boundary of the tolerance nearest to the nominal value. For this purpose, 21 capital letters are used to signify the position of the tolerance boundaries nearest to nominal holes, and 21 small letters are similarly used for shafts.

(*Concluded on page* 164)

Anti-Vibration Paints

By J. B. Slavik and J. Němec. (From *Strojírestvi*, Vol.1, No. 1, 1951, pp. 29-33, 7 illustrations, 5 tables.)

A series of experiments was carried out to determine the effect of several Czech-produced anti-vibration paints on the damping of vibrations, particularly those in the sonic range.

Preliminary Experiments.

An experimental paint produced by one of the authors and containing suitably prepared slag wool and varnish was tested on sheets 100 cm × 67 cm (40 in. × 26 in.) and 0·5 and 1 mm in thickness. The attenuation of the sound was measured by a subjective method in a totally noiseless room, using a stop watch. To produce the vibrations, the sheets were freely suspended and a wooden ball weighing 0·2 kg (0·44 lb) was dropped on its surface from a height which was identical for all the tests. The time was measured by two observers, and in each case the average of 20 readings was evaluated. The measuring accuracy was 15 to 20 per cent. The sound level at the moment of impact of the wooden ball on the sheet was measured by a General Radio Co., Type 759-A sound-level meter (in decibels), the microphone being placed at a distance of 150 cm from the sheet. Three alternative paints of this type were tested and the results obtained are summarised in Figs. 1 and 2 and Table I.

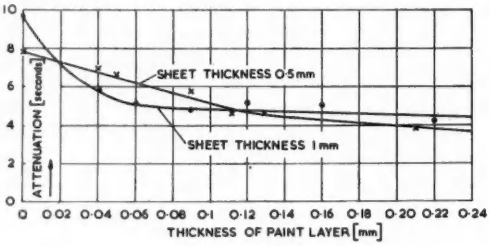


Fig. 1. **Influence of the anti-vibration paint A on sound attenuation.**

Anti-vibration Paint A.

The results obtained are given in Fig. 1. In the case of a 0·22 mm thick paint coating, the attenuation of the sound is reduced by about 50 per cent for 0·5 mm thick sheets, and by about 56 per cent for 1 mm thick sheets. In addition to the attenuation of the sound due to the impact, the attenuation of the sheet due to distortion also exerts an influence in the case of the thinner sheets. The paint had no influence on the sound level at the instant of impact. The paint is thinly liquid and can be sprayed on.

Anti-vibration Paint B.

The results obtained are given in Fig. 2. The attenuation of sound was reduced by about 78 per cent by applying a 0·43 mm thick layer of paint on a 0·5 mm thick sheet and by about 83 per cent in the case of a layer of 0·53 mm on a 1 mm thick sheet. In both cases, the paint layer brought about a reduction in the sound level at the instant of impact from 78 to 75·5 db, which corresponds to an approx. 44 per cent drop in the original sound intensity and an approx. 25 per cent drop in the sound pressure. High-frequency vibrations, which are the most unpleasant ones, were mainly affected by the damping. The paint can be sprayed on.

Anti-vibration Paint C.

The results measured are given in Table I. A 1·65 mm thick layer of paint on an 0·5 mm thick sheet reduced the attenuation of the sound by about 88 per cent and a 1·96 mm thick paint layer on 1 mm sheet

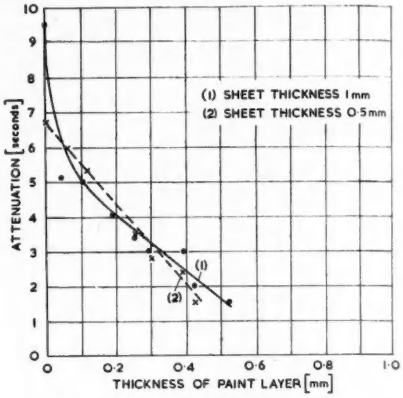


Fig. 2. **Influence of the anti-vibration paint B on sound attenuation.**

resulted in a reduction of about 84 per cent. The sound level at the instant of impact was thereby reduced by about 2 db. This paint has a higher viscosity and has to be applied with a brush. To obtain good adhesion of this paint, it is necessary first to apply a thin coating of paint A or B.

In sheets treated with this paint, the high sound

Table I. Anti-vibration paint C.

Thickness of paint layer [mm]	Attenuations [seconds]	Reduction of attenuation [%]	Sheet thickness [mm]
0	8·2	0	0·5
0·07	5·8	29	0·5
0·86	3·9	52	0·5
1·44	3·2	61	0·5
1·65	1·0	88	0·5
0	9·8	0	1·0
0·04	5·5	43	1·0
0·48	4·7	52	1·0
1·39	4·1	58	1·0
1·96	1·5	84	1·0

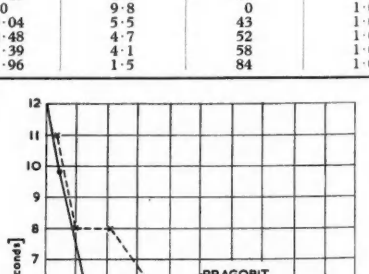


Fig. 3. **Attenuation as a function of the thickness of the paint layer.**

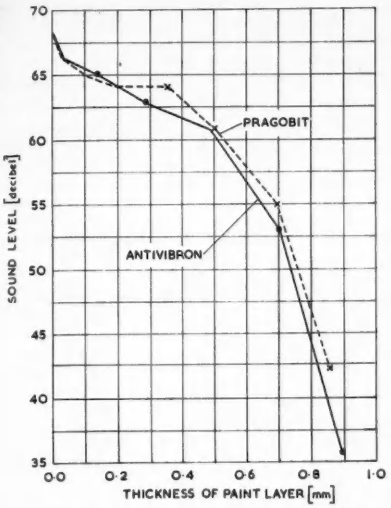


Fig. 4. **Sound level as a function of the thickness of the paint layer.**

frequencies disappeared completely and the remaining noise was not disturbing.

The above mentioned paints do not lose their anti-vibration properties as a result of drying in service, and this fact was confirmed experimentally. The paints adhere well to the surface; they do not develop cracks during their service life (about 7 years) and do not peel off as a result of impacts.

TEST RESULTS OBTAINED WITH "PRAGOBIT" AND "ANTIVIBRON."

The authors carried out a series of tests with "Pragobit A" containing natural asphalt as a main component, and "Antivibron" which is an improved version of the paints A, B, C mentioned earlier. For the tests, 0·82-mm thick sheet of 100 × 100 cm was used. The sheets were freely suspended and the sound was produced by dropping a wooden ball of 0·27 kg from a constant height.

The attenuation was measured electromagnetically by a pick-up and a recording instrument. The sound level at the moment of impact was measured by a Type 759-A General Radio Co. sound level meter placed at 150 cm from the sheet.

The sound level was also measured for continuous vibrations produced at the bottom corner of the sheet by a small electric motor attached to it which had a small mass fixed eccentrically to its shaft. The sound level was measured in a completely noiseless laboratory. The noise produced was analysed by applying the above mentioned sound level meter and an harmonic analyser, type 760, of the same make. The test results are summarised in Figs. 3 to 6.

As can be seen in Fig. 3, the attenuation for an 0·7 mm paint layer is reduced by 57 per cent in the case of Pragobit and by 76 per cent in the case of Antivibron. Antivibron has a higher specific gravity, and for equal weight of the paint layer, the percentage reduction of the attenuation is about equal for both paints.

An 0·86 mm thick layer of Pragobit-A reduces the noise at the instant of impact of the wooden ball by 4 db, and the corresponding reduction for an 0·89 mm thick layer of Antivibron is 8 db. The stronger effect of Antivibron is explained by its higher specific gravity; the weight difference in the above case was 0·55 kg.

The relation between sound level of a continuously vibrating sheet and thickness of the paint layer is plotted

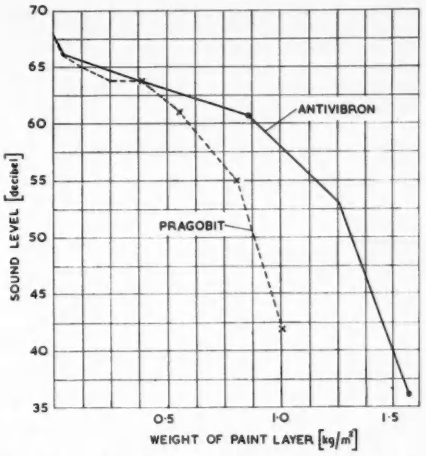


Fig. 5. **Sound level as a function of the weight of the paint layer.**

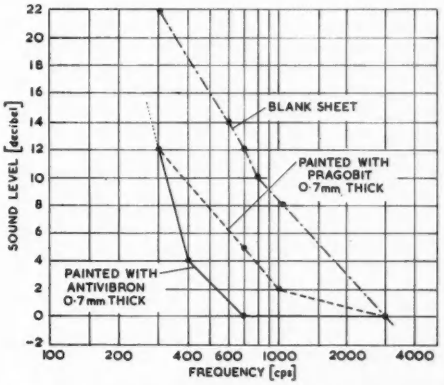


Fig. 6. **Comparison of the frequency spectra of vibrating sheets.**

in Fig. 4. An 0·7 mm thick layer of Pragobit-A reduces the sound level by 13 db; an equally thick layer of Antivibron reduces the sound level by 15 db. The weight of the paint layer is 0·77 kg/m² in the case of Pragobit-A and 1·25 kg/m² in the case of Antivibron. The sound level as a function of the weight of the applied paint layer is plotted in Fig. 5. The test results showed that there is an optimum minimum thickness of the paint layer, and an increase in the layer thickness above this minimum value brings about a considerable improvement of the noise conditions; it follows that the optimum values as regards the reduction of attenuation differ from those which bring about the largest reduction in the sound level.

Analysis of the sound spectrum of sheets subjected to continuous vibration showed that the spectrum was continuous up to approximately 4,000 cps in the case of blank sheets (Fig. 6). Antivibron proved to be particularly effective for damping vibrations of over 300 cps. The sound analysis was made with 3,000 cps as a reference frequency in all three cases (sheet blank, sheet painted with Pragobit, sheet painted with Antivibron) and, therefore, the values given for other frequencies are relative values only.

If exposed to the effect of steam, an approx. 0·85 mm thick layer of Pragobit-A softens considerably and smears if touched; after cooling down, it regains its

original shape and quality. Antivibron softens under equal conditions, but does not smear or stick if touched and regains its original properties after cooling down.

Pragobit begins to soften at 70° C, smears, and is sticky; at higher temperatures it becomes fluid, and at still higher temperatures it ignites and burns. Antivibron begins to soften at 80° C, does not become sticky and does not burn at higher temperatures, provided a suitable binder is used.

The basic constituent of Pragobit-A is asphalt, and Antivibron contains slag wool. The surface of Antivibron has a good appearance and can be made in different colours; since it contains slag wool, it should also have good heat-insulating properties.

Further tests are recommended on cars, tramways, railways or other fields of engineering where noise reduction is important.

By further additions as, for instance, minium, the paint can be made to serve also as an anti-corrosive agent.

SWITZERLAND

Tests on a High-Speed Two-Stroke Cycle Opposed-Piston Diesel Engine

By A. I. Ibrahim Abdelfattan. (From *Dissertation No.* 2053, *Federal Technological University* (*E.T.H.*), *Zurich*, 62 pages, 53 illustrations.)

This dissertation describes tests carried out on a Sulzer 2ZG9 engine. Comparative tests were made with standard Bosch-type injection equipment and with an accumulator injection system developed at the Institute for Thermodynamics & Engine Design.* The pump has a plunger provided with a central axial passage which communicates through an inclined transverse passage with the relief chamber at the beginning of the injection. The injection nozzle is of the pintle valve type and its accumulator chamber has a capacity of 6 cm^3. The fuel delivery per stroke was measured on a test rig described by Spillmann*. The delivery period was determined by two methods: (a) by stroboscopic observation of the crank-angle positions corresponding to the beginning and end of the injection, and (b) from recordings of the fuel spray impinging on the blackened surface of a test drum driven at half the pump speed. The time lag in the injection was found to correspond approximately to the time required by the pressure waves to travel along the fuel line to the nozzle. The quantity of fuel injected was determined by means of a multiple-cell type wheel, using also a 2-degree slot adjustable to various angular positions of the test drum. The fuel injected per unit time was obtained by weighing the quantities of fuel in the cells and the results were plotted in order to obtain the variation in delivery during the injection process. The tests were then continued on the engine. Pressure variations in the fuel lines were determined by piezo-electric means. The pressures in the accumulator chamber of the injection nozzle were calculated as functions of crank angle by various methods†. It was found that the accumulator system as regards fuel consumption gives results equal to those obtained with the standard injection equipment at a given speed depending on the injection timing. The smoke analysis showed an improvement over the standard pump, owing to improved atomisation and reduced secondary injection effects.

The scavenging conditions of the engine were then investigated. Each cylinder has its own piston-type scavenge blower. The air was aspirated through noise-reducing nozzles into an air receiver communicating with the inlet ports of the cylinder. The mean air pressure in the receiver, measured with a mercury manometer, was found to be practically unaffected by load, but extremely sensitive to engine speed. The pressure variations in the receiver were indicated by means of a crystal type pick-up and showed a fundamental frequency equal to twice the running speed (corresponding to the effect of the two scavenge pumps) and harmonics due to mechanical vibration of the pick-up and to travelling waves (acoustic oscillations) due to reflections from the inlet ports of the engine cylinder. The mean air temperature in the receiver was measured by means of a thermocouple shielded against direct radiation. It was found to be about 20° C higher than the outside air temperature at 1000 rpm, and about 30° C higher at 1500 rpm, the temperature showing also an increase of 5-10° C when the pressure in the air receiver was increased from 0 to 4·95 atm. Scavenge air measurements were corrected to take account of the effect of the measuring equipment, and the scavenge blower power was determined by calculation. Further measurements were also made of exhaust temperature and pressure fluctuations.

The degree of purity of the cylinder charge was determined by means of a gas sampling valve arrangement‡ comprising a rubber bladder, a non-return valve, and a device interrupting the fuel injection during the sampling by means of a manually-operated fuel control valve with an electro-mechanical relay connected to the crankshaft drive. It was found that the relative CO_2 content increases with load, for a given value of the scavenge air ratio. The degree of purity of the cylinder charge was also calculated by successive approximations, from equations for the fresh air charge, the residual gas, and the mixture in the cylinder, and the results showed close agreement with the measured values.

A detailed study was made of the various pressure losses, using cylinder pressure oscillograms, fuel consumption measurements, and results of running-down tests recorded photographically. Under full-load conditions, the fmep was 3·9 kg/cm^2, of which about 20 per cent was attributable to the scavenge pump. Of the remaining 3·06 kg/cm^2, 18·7 per cent was attributable to piston friction, and the remaining 81·3 per cent was mainly due to losses in the engine bearings‡‡.

Piston temperatures were determined with the aid of two thermo-couples on each piston. The lead ends were insulated in quartz tubes. The results showed that stable temperature conditions were reached in 5-8 minutes after starting. The temperature at the centre of the exhaust piston reached 760° C at full load. Piston temperatures showed an increase with load and running speed. The temperature distribution on the pistons was calculated by means of Eichelberg's formula, utilising the results of previous ETH investigations made by Eichelberg, Salzmann and Hug. At full load and 1500 rpm, the heat balance was determined as follows:— effective brake power 28·4 per cent, heat to cooling water 25·7 per cent, and exhaust gas heat 39·0 per cent.

* See: Spillman, dissertation, ETH, 1946.

† See: Spillman, loc. cit.; Eichelberg, Z.VDI, 1926; and Pischinger, Springer (Vienna), 1936.

‡ Developed by Dr. Ing. K. Elser, of the ETH.

‡‡ See: Horgen, Piston friction and leakage losses, Dissertation ETH, Zurich, 1942.

Instruments for Force and Temperature Measurement in Metal Cutting

By H. Opitz and K. Küsters. (From *Werkstatt und Betrieb*, Vol. 85, No. 2, February 1952, pp. 43-47, 17 illustrations.)

The measurement of cutting forces and temperatures on cutting tools constitutes an important aspect of metal cutting research. Owing to the wide variety of modern metal cutting processes, a large number of instruments and experimental rigs is required for this work, particularly as the measured variables fluctuate with varying frequencies, depending on the process under investigation. This report describes two methods of measurement developed in the Machine Tool and Production Laboratory of the Technical University at Aachen.

Tool force dynamometers are used for measuring forces when turning and shaping or planing. Four such instruments were developed, covering a range from 50 to 15000 kg. Generally, they measure the three force components, namely, the tangential, radial and feed force, but they can also be constructed for only one or two force components.

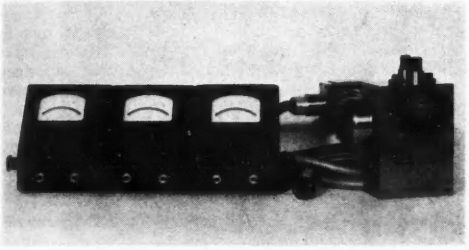


Fig. 1. **Three-component cutting tool dynamometer with indicating instruments.**

Fig. 1 shows a three-component dynamometer with its instruments, and a schematic view of its construction is shown in Fig. 2. The tool is held in a cradle attached to the housing by three front support bars and the forces are taken up by three measuring elements through connecting bars. All the bars have constrictions acting as elastic links. The actual measurement is carried out in the elements incorporating a thin diaphragm which deflects under the applied load. The magnitude of this deflection is measured by an electric induction circuit and is indicated on separate meters. A measuring unit is shown schematically in Fig. 3. The actual element is secured in the housing by a nut. It contains two U-shaped wound cores, with an interposed moveable

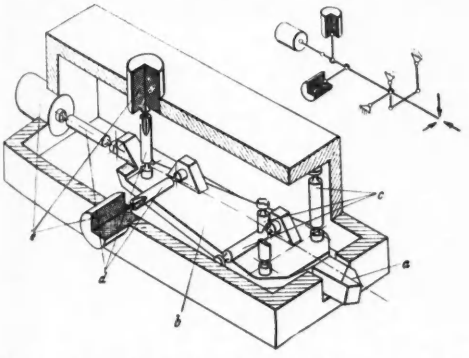


Fig. 2. **Schematic diagram of three-component cutting tool dynamometer.**
(*a*) Tool ; (*b*) cradle ; (*c*) front support bar ; (*d*) connecting bar, and (*e*) measuring element.

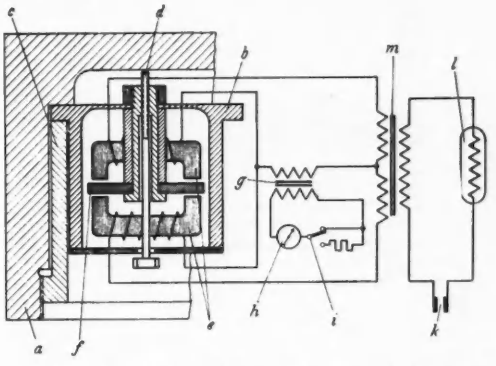


Fig. 3. **Circuit diagram of inductance measuring element.**
(*a*) Element housing ; (*b*) housing ; (*c*) locking nut ; (*d*) adjusting screw ; (*e*) fixed cores ; (*f*) moveable yoke ; (*g*) instrument transformer ; (*h*) meter ; (*i*) range selector ; (*k*) 22 volts, 50 cps mains supply ; (*l*) barretter resistance, and (*m*) mains transformer.

yoke. The yoke is attached to the steel diaphragm of the housing, which is pre-loaded so that the setting screw is in contact with the measuring diaphragm. The two core windings are connected in series and supplied from the secondary winding of a mains transformer. When load is applied and the yoke is displaced, the voltage distribution in the two windings is altered, causing a flow of current through the instrument transformer to the main transformer tapping. The deflection of the meter pointer is a measure of this current and, therefore, of the applied load. As the instrument is normally used on an a.c. supply, a converter has to be provided when only d.c. is available. A voltage stabiliser should be built in to deal with supply fluctuations.

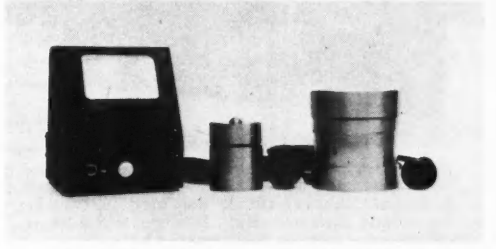


Fig. 4. **Measuring elements for 200 and 10 tons.**

The measuring elements are small enough to be used in confined spaces and are proof against shock loads. Low-frequency force fluctuations up to 2-3 cps can be followed on the meter. Frequencies up to approximately 20 cps can be traced on a vibrator type oscillograph or light spot indicator. Fig. 4 shows two elements for loads of 200 and 10 tons. Since the lowest measurable loading for the elements is approximately 50 to 100 kg, and it is frequently required to measure forces below 100 kg, e.g., when machining light alloys or finish machining with small chip cross-sections, another measuring system using strain gauges was developed.

The principles of strain gauge design and their characteristics are well known and need therefore not be dealt with here. The strain gauges were firmly attached to the upper and lower surfaces of the tool shank with a

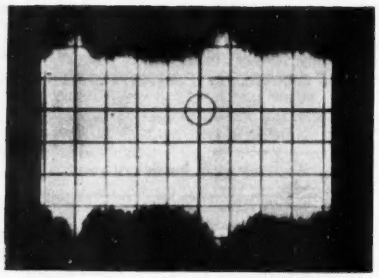


Fig. 5. **Force measurement when machining an Al-Si alloy.**

special cement, the lower surface having a milled recess to give more clearly defined bending. The two strain gauges and two fixed resistances were connected in a bridge network, which was supplied from a 1500 cps generator. The bridge output was fed to an oscillograph through a filter. A minute deflection of the tool due to the cutting force stretches the upper gauge and compresses the lower one. The consequent change in resistance causes an unbalance in the bridge, which is shown on the oscillograph screen. Fig. 5 shows an oscillogram of the cutting force when turning an Al-Si alloy, in which the abscissa represents the developed circumference of the component and the width of the band is a measure of the force. The force fluctuations are due to Si inclusions. The time base of the oscillograph was synchronised with the machine spindle speed to assist in evaluating the oscillograms.

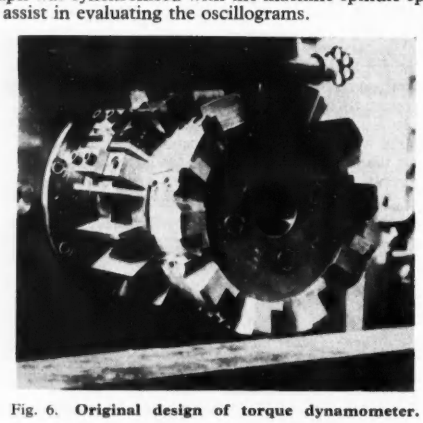


Fig. 6. **Original design of torque dynamometer.**

A similar electrical circuit was used for the first milling torque dynamometer. It employed an elastic torsion member, which was interposed between the milling spindle and the cutter. This dynamometer is shown in Fig. 6. The illustration shows some of the sixteen spring webs, which join the two flanges of the hub elastically. The relative angular displacement of the flanges was measured with strain gauges attached to critical points on the webs. The strain gauges were incorporated in the bridge circuit in such a manner that only the torsional forces were measured.

It was found that the bridge unbalance was not sufficiently pronounced for satisfactory measurement and it was decided to measure directly the angular displacement of the flange periphery. Two clamps were attached to opposite points on one flange, and a third clamp interposed between the two was attached to the other flange. The three clamps can be seen in Fig. 6, the opposite set is hidden by the cutter. A tensioned steel band was firmly attached to the three clamps with small fingers as shown in the illustration, and the strain

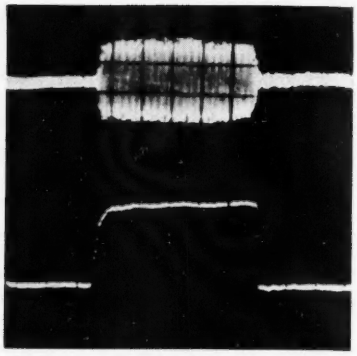


Fig. 7. **Oscillogram showing (a) torque, and (b) cutting temperature obtained with original dynamometer.** Cutting speed : 105 m/min ; material : Steel of 50 kg/mm² U.T.S. ; width of cut : 40 mm ; duration of cut : 0·0227 sec.

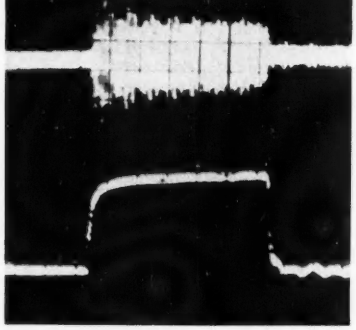


Fig. 8. **Oscillogram showing (a) torque, and (b) cutting temperature obtained with original dynamometer.** Cutting speed : 275 m/min ; material : steel of 50 kg/mm² U.T.S. ; width of cut : 40 mm ; duration of cut : 0·0087 sec.

gauges were cemented to the exposed parts of the band. The electrical connections to the strain gauges were taken through the hollow machine spindle to slip-rings at the rear of the machine. Difficulties arose owing to capacitance interference in this wire due to the 15000 cps supply, but these were largely overcome by inserting the wiring in a brass tube fitted to the machine spindle. A normal rubber-covered wire was found to be most suitable.

After these modifications, the bridge unbalance was quite adequate for obtaining suitable measurements at normal cutting speeds. Figs. 7 and 8 show two force measurements on steel of 50 kg/mm² U.T.S. at various speeds. The width of the band is a measure of the torsional force, whereas the shape of the curve indicates the thermo-electromotive force measured by the "one-tool method." The latter is a function of the temperature on the cutting tool. These measurements showed that a normal milling cutter was not suitable due to its great mass. As shown in Fig. 9, considerable vibration occurred even at about 300 m/min and oscillograms taken at higher speeds are almost valueless. A new torsion member was therefore developed, in which the cutter had a very light mounting attached to a heavy flywheel. The principle of this design is shown in Fig. 9. A wedge-shaped tool cradle was formed by milling two L-shaped slots in the heavy flywheel ; the tool cradle is supported on the periphery by four narrow tension members. The tool is clamped in a bore in the tool cradle and the natural frequency of this arrangement is very much higher than that of the design previously described.

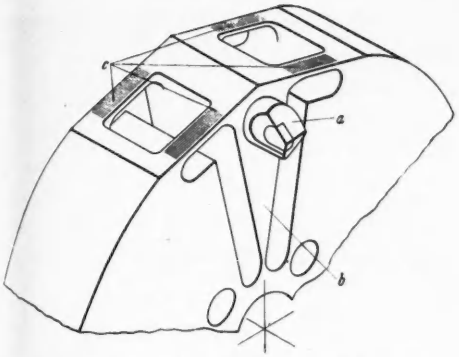


Fig. 9. **Torque dynamometer, second design.**
(*a*) Cutter; (*b*) tool cradle, and (*c*) narrow tension members.

The strain gauges, which are cemented to the narrow members, are again connected to a bridge in such a manner that the cutting force is measured independently of the tool overhang. During actual cutting, the swarf tended to damage the strain gauges despite all precautions and sheet metal guards, covering the slots, were therefore designed. These were attached to the front and rear of the flanges and were fitted over a layer of thick paper. This served as a friction damper for the interfering vibration of the tool cradle, and it was found in subsequent tests that this damping was just adequate.

The 15000 cps carrier frequency of the strain gauge supply caused many difficulties in the early tests, and this was particularly troublesome in view of the intention to increase the sensitivity of the whole instrument. Carrier frequency supply was originally chosen because the amplifier, without which the strain gauges were not useable, could only operate on an alternating current supply. The supply to the amplifier had also to be a.c. during the static calibration of the instrument, as is the case with a carrier frequency supply. The frequency of 15000 cps was chosen because it was intended to investigate forces as the tool entered and left the cut material. The time taken for this is extremely short.

One requirement from the second instrument was a tenfold increase in sensitivity compared with the original instrument. Due to the above mentioned difficulties with the carrier frequency supply, it was decided to use a direct current supply. This was possible since only one tool was to be used and, therefore, the cutting force and the corresponding potential were in the form of an impulse, i.e., alternating. To achieve a further increase in sensitivity, the highest current available from the power supply unit was employed. The bridge output was to be amplified in a battery-fed amplifier and only then fed into the oscillograph. A very strong 50 cps hum was detected and this could not be removed by various attempts at capacitive and magnetic screening.

As seen in the final circuit diagram in Fig. 10, this hum was due to the earthing of the bridge output and also due to the fact that the bridge unbalance potential was in opposite phase at both bridge output points, whereas the interference potential was in phase. The interference could largely be prevented from reaching the amplifier by interposing a screened isolating transformer. Moreover, the transformation ratio allowed a further increase in sensitivity. The transformer laminations were manufactured from the best-quality material to achieve minimum stray; the dimensions of the transformer were governed by the values of the frequencies involved. The difficulties due to the static calibration were also solved. When a constant calibration load was applied to the cutter, a direct current bridge potential was caused and this was given a square wave form by a relay operating in synchronism with the 50 cps supply. Alternating voltage was thus created and could be fed into the isolating transformer. Further strong hum interference was detected here, and this could be removed by separating the relay contact leads from the terminal block and taking them out individually.

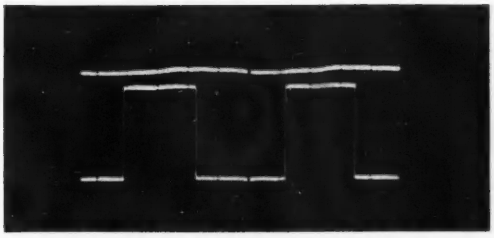


Fig. 11. **Oscillogram of thermoelectric calibration.**

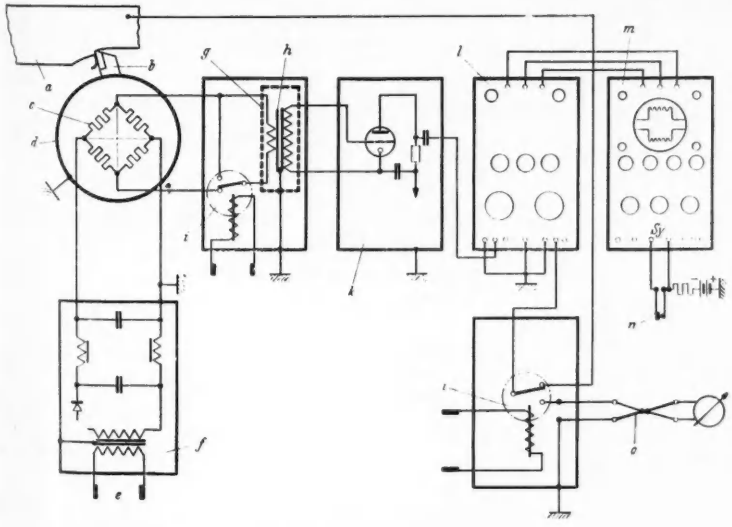


Fig. 10. **Schematic circuit diagram of cutting force and cutting temperature measuring test rig for milling.**
(*a*) Insulated clamped workpiece; (*b*) cutter; (*c*) strain gauge bridge; (*d*) cutter-head and dynamometer; (*e*) 220 volt, 50 cps mains; (*f*) rectifier unit; (*g*) magnetic screening; (*h*) isolating transformer; (*i*) square wave generator, 50 cps (2V supply); (*k*) battery-fed amplifier; (*l*) Philips switch unit; (*m*) Philips cathode-ray oscillograph; (*n*) synchronising contact, and (*o*) thermoelectric calibration element.

A similar arrangement was used for calibrating the temperature indicator, but due to the considerably lower amplification, the tendency towards hum interference was much smaller. An oscillogram of a calibration is shown in Fig. 11; further oscillograms obtained with this instrument in actual use will be shown in a later publication.

The whole experimental set up is shown in Fig. 12, mounted on a horizontal milling machine.

The leads from the rotating dynamometer were taken through the hollow spindle to slip rings at the rear of the machine, Fig. 13. Considerable difficulties, requiring a great deal of attention, were experienced in connection with the slip rings. Carbon brushes and carbon slip rings were used originally. These were quite satisfactory as long as the rings retained their ground surface. However, once this surface was worn smooth, it caused a strong and erratic interference voltage which had to be suppressed. It seems that when using carbon on carbon, the unavoidable minute vibration of the brushes causes a greater interference potential than with other materials. A new slip-ring design was then developed, in which the brush holders were mounted in ball bearings on the slip-ring carrier and not on the machine frame itself. The brush vibration was thus considerably reduced, but accurately concentric rotation of the slip rings had also to be ensured. The slip-rings were finally made from hard-drawn brass, with two copper-base brushes per ring. The carbon brushes already used were rejected, as, contrary to existing information, they caused interference. The wear when running copper brushes against brass rings was small, and after 300 hours' running, only 0·5 mm wear could be detected. Interference due to the thermocouple effect was negligible as the rings were turned from one bar and the brush material also originated from one heat. The surface speed of the rings lay between 0·2 and 6 m/sec. The contact for the synchronisation of the cathode-ray oscillograph was situated on the brush holder. The brush holder could be rotated through 360 degrees and held in any position to permit the setting of the contact.

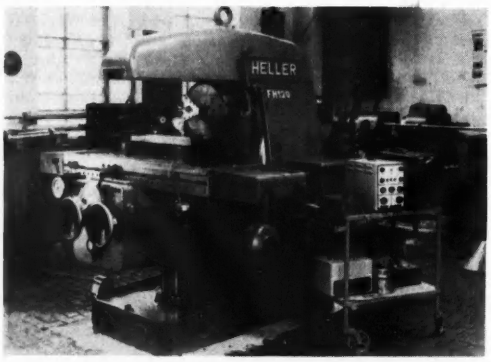


Fig. 12. **Complete installation for cutting force and cutting temperature measurement as used on a Heller milling machine.**

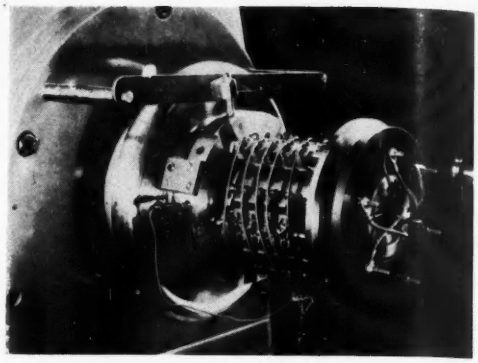


Fig. 13. **Brush holder mounting at the rear of the milling machine.**

The development of the above equipment involved numerous difficulties and necessitated experiments for establishing the most suitable materials for its construction. After all these difficulties were investigated and solved, the equipment was successfully used for experiments, which, it is hoped, will contribute towards the clarification of metal cutting problems.

RUSSIA

Accelerated Starting of Ward-Leonard Type Drives

By V. V. Roodakov. (From *Elektrichestvo*, No. 9, 1951, pp. 49-53, 5 illustrations.)

The author analyses the starting process of Ward-Leonard sets, and shows that acceleration of starting requires boosting of the generator field excitation, though in low-powered sets the main source of delay is dynamic inertia. A relay-controlled circuit with a series resistance in the generator field circuit, short-circuited during starting, produces desirable characteristics. Feedback circuits do not, unless a non-linear characteristic is introduced. A recommended circuit employing an "amplidyne" type electromechanical amplifier and dry rectifying elements is described.

Clearly, the quickest starts are possible when the maximum permissible acceleration determined by the torque capacity of the transmission is maintained throughout the starting process.

A Ward-Leonard set with an independently excited motor field, assuming that the driven machine has a constant braking torque, requires a constant starting current for uniform acceleration, since the motor torque, which is proportional to the armature current, consists of the sum of the braking torque and the inertia torque.

The condition of constant starting current means, if armature inductance is ignored, a linear increase in the motor armature voltage :

$$U_a = C_1 n + I_m R$$

where I_m is the motor armature current and R the armature resistance with constant acceleration $n = At$, hence :

$$U_a = C_1 A t + C \quad .. \quad .. \quad (1($$

But the e.m.f. of the generator rises proportionally with its field current : $E_2 = C_g i$. Hence, to ensure a linear rise in the motor armature voltage, it is necessary to arrange a linear rise in the exciting field current of the generator.

Consequently, the voltage in the generator field

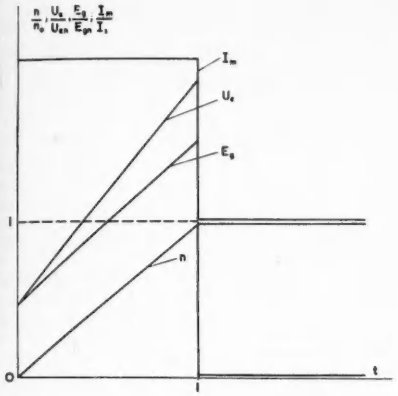


Fig. 1.

U_e = voltage in generator field winding ; E_g = e.m.f. of generator ; I_m = motor armature current ; I_s = short-circuit current of generator and motor armature windings ; suffix n = normal, i.e., steady state.

winding must obey the expression :

$$U_e = r\frac{C_1}{C_2}A\left(T + B + \frac{R}{A}\frac{M_B}{A\,C_1\,C_2} + t\right) \qquad (2)$$

where A = angular acceleration (maintained constant),
T = " time constant " of generator field winding,
B = " time constant " of transmission,
C_1 = coefficient of proportionality between the counter-e.m.f. of the motor and its rpm,
C_g = coefficient of proportionality between the e.m.f. of the generator and its exciting current,
M_B = braking torque of transmission,
C_2 = coefficient of proportionality between the armature current and the torque of the motor, and
r = resistance of generator field circuit.

Fig. 1 illustrates the curves of generator field voltage, generator e.m.f. and motor armature current in a driving set fulfilling the above demands. In order to achieve these conditions, the e.m.f. of the generator must be artificially boosted. Methods of performing this task are reviewed in the following.

The sudden switching-in of the generator field winding into a supply of a given voltage results in a starting process represented by :

$$n = \frac{n_o}{T-B}\left[T\left(1 - e^{-t/T}\right) - B\left(1 - \gamma\, e^{-t/B}\right)\right] - \Delta n_B \qquad (3)$$

where $\gamma = e^{-t_{st}(B-T)/BT}$,

t_{st} = time interval between the moment of switching-in of generator excitation and actual starting of motor,
Δn_B = reduction in motor speed owing to braking torque, and
n_o = established no-load speed of motor.

The time to achieve nominal speed is determined by the larger of the two time constants T and B. In practice, $T > B$ corresponds to a system of about 7000 hp, in which $T = 2{\cdot}75$ sec and $B = 0{\cdot}0425$ sec are average values. At the other end of the scale, $B > T$ represents small sets of, say, 250 W, in which $T = 0{\cdot}01$ sec and $B = 0{\cdot}035$ sec. Clearly, to be accelerated, powerful systems require the boosting of the electro-magnetic transition process, represented by the time constant T, in the exciting circuit of the generator. Small driving sets need a boosting of the dynamic transition process, represented by time constant B, of the motor with its driven load.

Fig. 2 shows a boosting method of generator excitation with the help of a resistance, short-circuited during the starting process, and automatically introduced into the circuit upon attainment of the required motor speed.

Without impairing the general validity, it is assumed, for the sake of simplicity, that the braking torque of the driven machine is zero.

Examining this case with the help of eq. (3), it is found that the time interval to achieve nominal speed becomes :

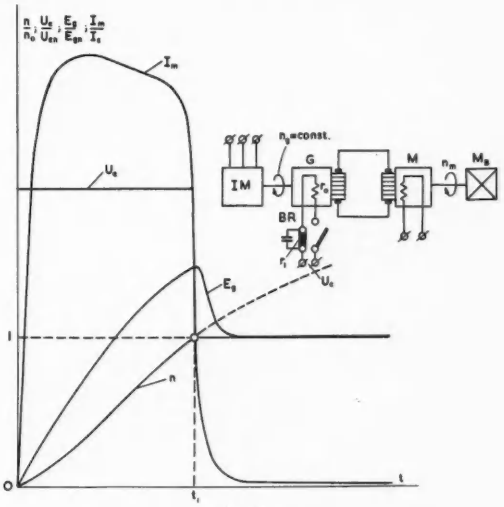


Fig. 2.

IM = Induction motor ; G = generator, M = motor ; n_m = motor rpm ; M_B = braking torque ; BR = boosting relay ; n_g = generator rpm.

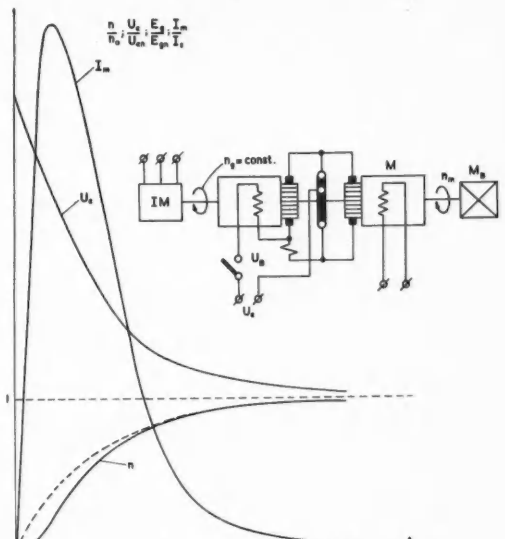


Fig. 3.

$$\left.\begin{aligned} t_1 &= T \ln\left(\frac{\alpha}{\alpha - 1}\right) \text{ for a system with } T > B \\ t_1 &= B \ln\left(\frac{\alpha}{\alpha - 1}\right) \text{ for a system with } B > T \end{aligned}\right\} \quad (4)$$

where α is the ratio of the boosted to the nominal generator field voltage which will be known as the boosting coefficient.

The curves in Fig. 2 describe the starting process. We note particularly the almost constant value of the motor armature current I_m during the starting operation. The disadvantage of this method is the need for automatic relay control.

Fig. 3 shows a generator field circuit with a feedback from the generator e.m.f. The effective generator field voltage is less than the full supply voltage by the voltage drop in a portion of a resistance across the armature.

Obviously, the generator field will first be energised by the full supply voltage, but the effective voltage will drop gradually to its nominal value as the generator e.m.f. reaches its steady value.

Again assuming no braking torque in the driven machine, the time intervals for accelerating to nominal speed become :

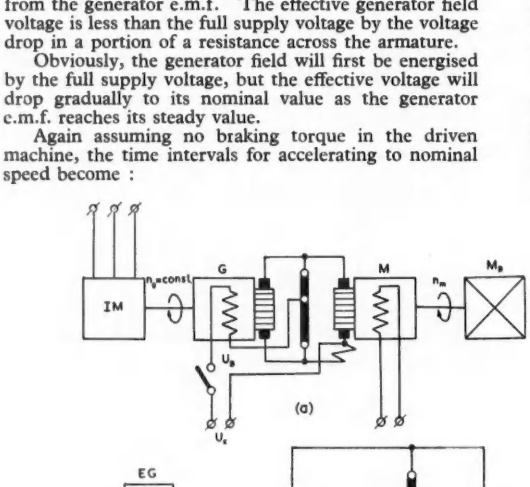


Fig. 4.
EG — exciting generator.

$$\left.\begin{aligned} t_1 &= (4 \text{ to } 5)\,\frac{T}{1 + \beta S} \text{ for a system with } T > B \\ t_1 &= (4 \text{ to } 5)\,B \quad \text{for a system with } B > T \end{aligned}\right\} \quad (5)$$

where $1 + \beta S = \alpha$ and β is a measure of feed-back (see below).

The curves in Fig. 3 show that acceleration in this case is non-uniform and the armature current falls rapidly during the starting period following an initial peak.

Fig. 4a shows a boosting method of generator excitation, by means of a feed-back from the e.m.f. of the motor.

Mathematical investigation of the starting process results in the following expressions for starting times :

$$\left.\begin{aligned} t_1 &= (4 \text{ to } 5)\,T/[(1 + \Delta)/2 + T(1 - \Delta)/(2B)] \\ &\quad \text{for systems with } T > B \\ t_1 &= (4 \text{ to } 5)\,B/(1 + \Delta)/2 + B(1 - \Delta)/(2T)] \\ &\quad \text{for systems with } B > T \end{aligned}\right\} \quad (6)$$

where

$$\Delta = \sqrt{1 - \frac{4\beta S B T}{(B - T)^2}},$$

$\beta = \dfrac{U_B}{E_{mn}}$ = feedback coefficient,

$S = \dfrac{E_2}{i_e r_o}$ = amplification coefficient of generator voltage,

i_e = generator field current,
r_o = resistance of generator field winding,
U_B = feed back voltage, and E_{mn} = motor e.m.f.

The starting process with this circuit is not very different from that of the preceding arrangement, but this time a low power set with $B > T$ is also accelerated. This is shown by eq. (6) which, in contrast with eq. (5), does differ from the equation representing an unboosted start.

In Fig. 4b a boosting arrangement is shown in which a non-linear feedback between motor e.m.f. and generator excitation exists. Non-linearity is introduced by the saturation characteristics of the exciter *E G* and by the rectifying action of the dry rectifiers K_1 and K_2.

As a source of voltage for the generator field winding, a rotating electro-mechanical amplifier of the cross-field type (" amplidyne ") is used, which may be considered practically inertialess. When the field windings O_1 and O_2 of the exciter are first switched-in, the feedback is totally ineffective. The design of the magnetic circuit of the amplidyne is such that in this position of over-excitation the field is saturated, and the generator field winding does not receive an excess voltage. When the feedback becomes progressively more effective with the rise in motor e.m.f., owing to its rising speed, the saturation of the magnetic field in the exciter is reduced. Eventually, the field passes into the unsaturated part of its characteristics. Furthermore, with the approach of nominal motor speed, the feedback voltage, which is the voltage drop across resistance r_2, exceeds the supply voltage U_s, and rectifier element K_1 blocks the passage of current, while rectifier element K_2 takes over and short-circuits resistance r_3. At this point, the feedback voltage begins greatly to influence the output voltage of the amplidyne, until, towards the end of the starting period, this voltage is reduced to its nominal value.

The nature of the starting process in the last-mentioned arrangement is very similar to that illustrated in Fig. 2. The desirable results of that system can therefore be achieved without relay control.

Analysis gives the following expressions for the starting times :

$$\left.\begin{aligned} t_1 &= T \ln\left(\frac{\alpha_{min}}{\alpha_{min} - 1}\right) \text{ for a system with } T > B \\ t_1 &= B \ln\left(\frac{\alpha_{min}}{\alpha_{min} - 1}\right) \text{ for a system with } B > T \end{aligned}\right\} \quad (7)$$

where α_{min} is the minimum value of the boosting coefficient defined above. More precisely, α_{min} is the ratio of the maximum to the minimum voltage impressed on the generator field winding during the actual starting process.

Industrial Applications of Sonic Energy

By C. R. SODERBERG, Jr. (From *Iron and Steel Engineer*, Vol. 29, No. 2, February, 1952, pp. 87-94, 22 illustrations.)

This article describes the sonic wave generators and associated equipment required for the agglomeration and collection of dust and fumes from industrial plants. It also outlines the possibilities of sonic processes for the emulsification, demulsification and degassing of liquids.*

A SONIC collection system consists basically of an agglomerator chamber or tank, a sonic wave generator driven by compressed air, and a secondary collector. In the agglomerator chamber, the dust or mist is separated from the gases as a result of particle agglomeration and precipitation produced by means of sonic waves (not "ultrasonic," since most generators work in the audible range of frequencies). The intensity or rate of energy transfer is measured in watt/cm², hp/ft², or on a logarithmic scale in terms of decibels. The intensity in a typical agglomeration vessel is approximately 160 decibels, which corresponds to a pressure amplitude of 0·238 psi for a plane sinusoidal progressive wave. The waves in the agglomeration tank, however, are reverberated and travel in all directions. In spite of the high intensities generated at audible frequencies, the sound insulation is so effective that a normal conversation can easily be carried on next to these tanks.

SONIC GENERATORS FOR GASES.

There are two basic types of mechanical sound generators : (a) the axial type, which consists of a duct with a rotary disc valve at one end, and (b) the radial type, which comprises a rotor and a stator sleeve fitted one over the other and provided with a number of peripheral ports.

The radial generator has to be situated in the agglomeration tank, since the sonic energy is emitted radially. The gases must therefore flow through the high-intensity region surrounding it. As the process gases are hot (300-400° F) and usually corrosive, they will attack lubricated surfaces and reduce the bearing life of the radial generator. Although acoustically efficient, this generator presents, therefore, severe difficulties as regards maintenance and operation.

To overcome these difficulties, the axial generator was developed. Owing to its favourable location at the top end of the agglomerator tank over the gas inlet, it is easily accessible without interfering with the gas flow†. As a result of considerable development work, resulting in an improved acoustic and aerodynamic design of the horns and rotors, the efficiency of the axial generator has been increased from 10 per cent to its present value of 50 per cent.

In work of this kind, it is necessary to measure the acoustic energy output. Crystal microphones were not found satisfactory, since their calibration is generally at a 120-db level, whereas the intensities considered are of the order of 160 db. Good results were obtained by using a thermodynamic method, in which the sound generator is mounted on an acoustically insulated box which simulates free field radiation and the horn is covered by a diaphragm. By measuring the temperature drop through the siren, the energy available for acoustic radiation can be obtained, the heat transfer being eliminated by adequate heat insulation.

AGGLOMERATION.

The agglomeration vessel must be designed to contain a field of maximum intensity. The energy flow in the vessel is illustrated in Fig. 1. The input energy provided by the generator compensates for the tank

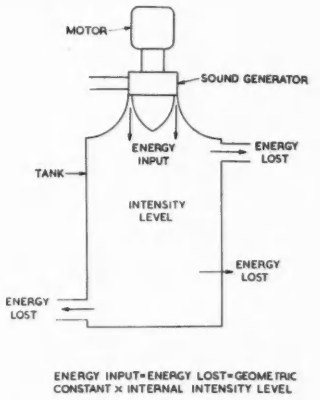


Fig. 1. **Diagram of energy flow in agglomeration vessel.**

losses (port and wall losses) which are proportional to the intensity level. The tank operating intensity is reached when the intensity level builds up to a point where the losses balance the input.

Although the mechanism of agglomeration is extremely complex, it is possible to visualise the sound field in the agglomeration chamber as consisting of a series of pulsating pressure gradients, associated with vibratory velocities of the gas which induce oscillations of the suspended particles. The peak velocities and phase angles of these particle oscillations, relative to those of the sonic field, depend on the ratio of the particle mass to its drag coefficient. Large particles tend to remain stationary, whereas small particles follow more readily the velocity variations of the gas and thus reach appreciable velocities. As a result, collisions occur and a proportion of the small particles adhere to the larger ones and are collected with the same efficiency as the larger particles by the secondary collector.

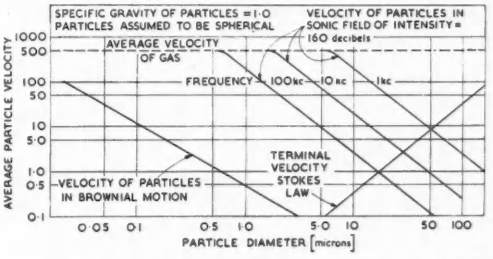


Fig. 2. **Particle velocities for various types of motion.**

The gas containing entrained dust or mist is known as an "aerosol." The aerosol particles can have three types of velocities of motion, as shown in Fig. 2, viz. : (a) velocities of Brownian motion, (b) settling velocities, as determined by Stokes' law, and (c) induced vibratory velocities, depending on particle size, field intensity and frequency of excitation. The three curves for frequencies of 100, 10 and 1 kcps included in Fig. 2

*Another article on this same subject was published in "*The Engineers' Digest*," January, 1950, pp. 14-16.

†A drawing of a plant with this type of generator was published in the article referred to above.

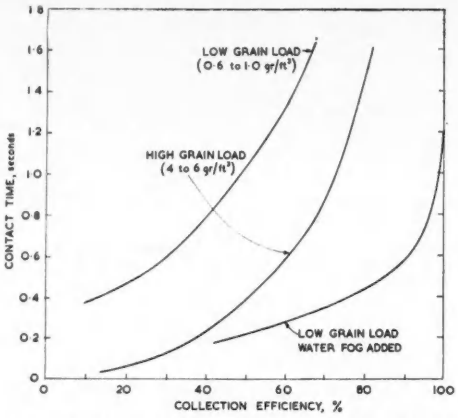


Fig. 3. **Collection efficiency of 93·5-95 scale furnace black as function of exposure time.**

indicate the rms velocities of particles with a specific gravity of unity, in a gas with a molecular weight equal to that of air, and in a sound field of 160 db. These curves show that for particles between 3 and 10 microns, low frequencies give greater relative velocities and are therefore more favourable for agglomeration than high frequencies.

If the " grain loading " or concentration (i.e., the weight of entrained material, regardless of size, in grains

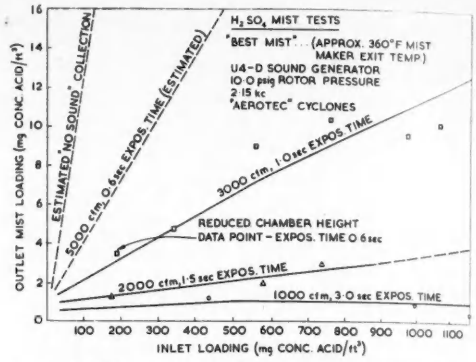

H₂SO₄ MIST TESTS
"BEST MIST"... (APPROX. 360°F MIST MAKER EXIT TEMP.)
U4-D SOUND GENERATOR
10·0 psig ROTOR PRESSURE
2·15 kc
"AEROTEC" CYCLONES
"ESTIMATED" NO SOUND" COLLECTION
5000 cfm, 0·6 sec EXPOS. TIME (ESTIMATED)
3000 cfm, 1·0 sec EXPOS. TIME
REDUCED CHAMBER HEIGHT
DATA POINT – EXPOS. TIME 0·6 sec
2000 cfm, 1·5 sec EXPOS. TIME
1000 cfm, 3·0 sec EXPOS. TIME
OUTLET MIST LOADING (mg CONC. ACID/ft³)
INLET LOADING (mg CONC. ACID/ft³)

Fig. 4. **Performance of sonic acid-mist collection system.**

necessary to make pilot plant tests in order to determine the agglomerator performance.

Pilot plants have been successfully operated for the collection of carbon black, sulphuric acid mist, and open-hearth fumes. Full-scale installations have been constructed for the first two applications, and a proposed layout has been developed for a 24,000 cfm open-hearth furnace.

The pilot plant for carbon black had an agglomeration vessel and three cyclones in series as the secondary collector. The increase in collection obtained with increased inlet fume concentration was as follows, using a U4 generator and a 10 psig rotor pressure:—

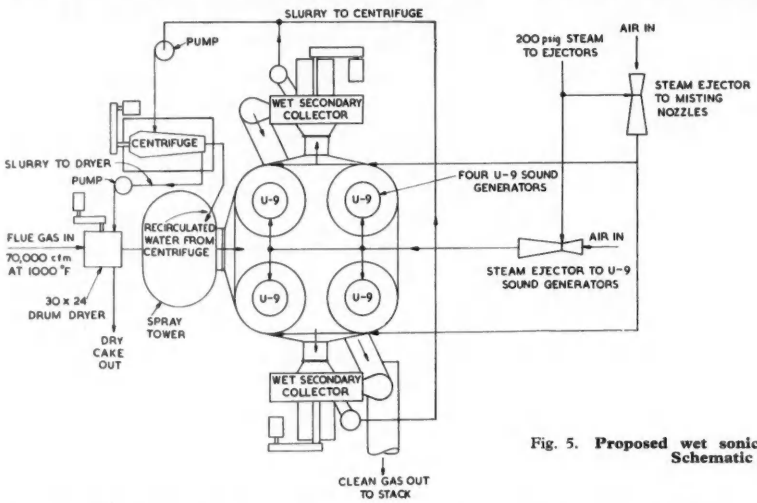


Fig. 5. **Proposed wet sonic open-hearth fume collector. Schematic flow diagram.**

or milligrams per cubic foot of gas) is not large enough, the particles may not strike many others or may not adhere, even though they are subjected to large-amplitude vibrations. In such cases, increased collection efficiency is obtained by adding water mist to the aerosol (see Fig. 3).

TYPICAL APPLICATIONS

As shown in Fig. 2, to obtain agglomeration there must be large particles of 5-10 microns to which the smaller particles can adhere. The problem of size distribution is thus of primary importance for the operation of a sonic agglomerator. However, an accurate particle size determination of a proposed field installation is practically never available, so that it is

Intensity × exposure time	Grain loadings (grains/ft³)			
	0·4	1·0	2·0	4·0
(watt/cm²) × sec	Collection efficiency—per cent			
3·3	60	77·5	85	89·5
7·0	70	86·0	93	98·0

The performance of the sulphuric acid pilot plant is shown in Fig. 4.

The tests with the pilot plant equipment recently used on an open-hearth furnace were divided into three main groups:—(1) Dry tests. These showed that excessive power was needed to agglomerate the fume in the dry state. (2) Semi-dry tests, using the secondary collector only. (2') Semi-dry tests, using a sonic agglomerator and spray-saturated gas to collect the

fume as a moist powder, showed an appreciable improvement. (3) Wet tests, first using the secondary collector only. (3′) Wet tests, showing further improvement, with a wet secondary collector, the gas being spray saturated, and the fume collected in a slurry. The results of the tests under the various conditions are summarised in the following table.

Test conditions :	(1)	(2)	(2′)	(3)	(3′)
Inlet (fume available for collection)	Grain loading (grains/ft³) —	8·3	3·75	0·75	0·3
Outlet	—	—	1·60	0·67	0·08–0·12

The collection efficiency obtained in the wet tests is thus 75-82 per cent. In the proposed full-scale installation on a 24,000 cfm open-hearth furnace (Figs. 5 and 6), the product is collected from the drum drier

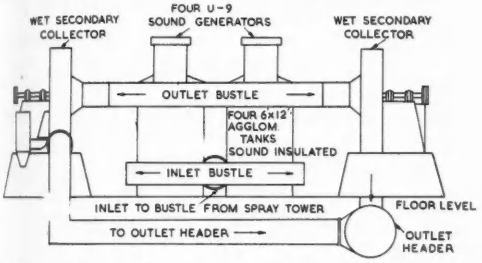


Fig. 6. **Elevation of proposed wet sonic open-hearth fume collector.**

in the form of a dry cake. The steam consumption is calculated as approximately 1200 lb per hr per 1000 cfm of treated gas, corresponding to a power input of 15 hp per 1000 cfm if compressed air is used.

SECONDARY COLLECTORS

The impingement separator used is predominantly an open-area, woven-wire inertial separator. A comparison of this separator with the conventional centrifugal separators is shown in Fig. 7. It is being used successfully in cement kilns, oil fume collectors, and spray driers for soap. The high collection efficiency possible with a conventional centrifugal separator does not suffice. By preconditioning the gases and proper

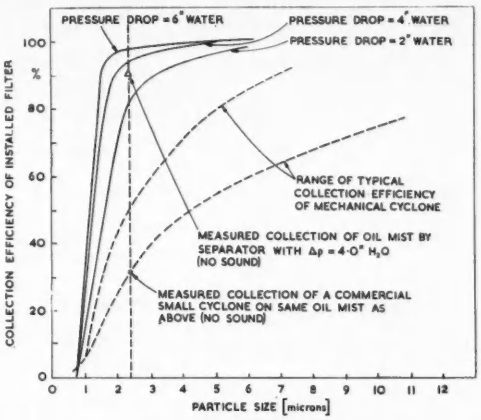

PRESSURE DROP = 6" WATER
PRESSURE DROP = 4" WATER
PRESSURE DROP = 2" WATER
COLLECTION EFFICIENCY OF INSTALLED FILTER
100
%
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12
PARTICLE SIZE [microns]
RANGE OF TYPICAL COLLECTION EFFICIENCY OF MECHANICAL CYCLONE
MEASURED COLLECTION OF OIL MIST BY SEPARATOR WITH Δp = 4·0" H₂O (NO SOUND)
MEASURED COLLECTION OF A COMMERCIAL SMALL CYCLONE ON SAME OIL MIST AS ABOVE (NO SOUND)

Fig. 7. **Theoretical collection efficiency of water droplets in air by typical separation units.**

filter washing, the impingement separators can be applied to solids, such as cement and iron fume. Cement dust can be collected in this kind of wet collector without turning the filter element into a piece of reinforced concrete. A 10,000 cfm impingement separator is now operating in the cement industry.

SONIC GENERATORS FOR LIQUIDS

Sonic energy generators can be used to process substances either as liquids or as gases. Emulsification, i.e., the intimate mixing of two liquids, can be obtained by sonic generators when cavitation (formation of low-pressure vapour bubbles) is present in the liquid. Standing waves can also be used for degassing, demulsification (separation of liquids) and coagulation of solids in liquids. There are also applications of emulsification in metallurgy : by agitating the molten metal, products with different properties can be obtained. Sonic means of agitation can also be used for keeping fresh liquid in contact with metal parts, in pickling tanks and metal washing systems. Other possible applications are being considered for the paper drying and paper coating industries.

RUSSIA

Simple Method of Independent Capacity Measurement

By A. E. FUERSTENBERG. (From *Elektrichestvo*, No. 8, 1951, pp. 72-74, 2 illustrations.)

The author describes equipment for measurement of the value of a capacity at mains frequency. This equipment includes only one variable and two fixed resistances, the values of which must be precisely known, but no calibrated or variable condensers. The complete equipment includes a transformer, a wave filter, and a simple electronic amplifier. Instructions for applying the method are given, and its maximum error is found by analysis and test to be of the order of 0·3 per cent.

The proposed method of measurement consists of balancing the voltage drops in the resistances, R_1 and R_3 (Fig. 1).

If the supply is sinusoidal and the circuit is in equilibrium (i.e., $U_{A3} = U_{B3}$), then obviously

$$\frac{U}{\sqrt{\left(\frac{1}{\omega C_x}\right)^2 + R_1^2}} R_1 = \frac{U}{R_2 + R_3} R_3$$

Later, it will be shown that $R_1 \ll 1/(\omega C_x)$, which allows of neglecting the second term under the square root, hence :

$$C_x \approx \frac{1}{\omega R_1} \frac{R_3}{R_2 + R_3} \quad .. \quad .. \quad (1)$$

where C_x = capacity in farads.
R_1, R_2, R_3 = active resistances in ohms.
ω = frequency in radians/seconds.

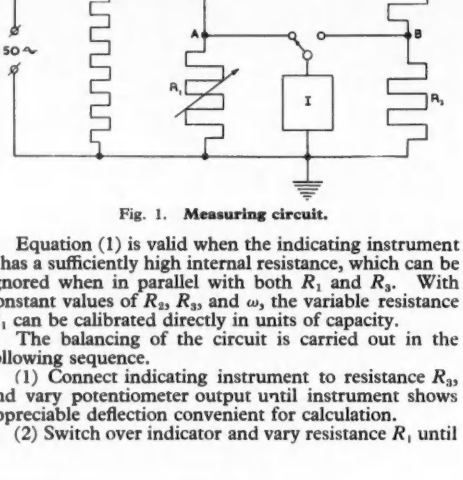


Fig. 1. **Measuring circuit.**

Equation (1) is valid when the indicating instrument I has a sufficiently high internal resistance, which can be ignored when in parallel with both R_1 and R_3. With constant values of R_2, R_3, and ω, the variable resistance R_1 can be calibrated directly in units of capacity.

The balancing of the circuit is carried out in the following sequence.

(1) Connect indicating instrument to resistance R_3, and vary potentiometer output until instrument shows appreciable deflection convenient for calculation.

(2) Switch over indicator and vary resistance R_1 until the same indicator reading appears.

(3) To check constancy of input voltage, the sequence is repeated once or twice and, if necessary, resistance R_1 is corrected.

The error due to higher input harmonics, if the indicating instrument possesses a quadratic characteristic, is given by the following expression :

$$\delta_H = \left[\sqrt{\frac{1 + 4(U_2/U_1)^2 + 9(U_3/U_1)^2 + \ldots}{1 + (U_2/U_1)^2 + (U_3/U_1)^2 + \ldots}} - 1 \right] 100\% \qquad (2)$$

where the amplitude of the fundamental frequency is U_1, and U_2 and U_3 are the amplitudes of the corresponding harmonics.

With the use of a simple wave filter in accordance with Fig. 2, it is possible to eliminate the influence of the harmonics in the supply voltage. For reliable results, the transformer should at least be rated at 50 VA. Its secondary winding must have an output voltage of 150-170 V.

Voltage control for the input of the measuring circuit must not be carried out by a variable resistance in the primary circuit of the transformer, since this would cause an appreciable distortion of the sinusoidal form of the input voltage.

The most suitable indicating instrument is a simple resistance-coupled amplifier with a rectifier in its plate circuit. A micro-ammeter in the rectifier bridge indicates the balance, and should have a sensitivity of 0·2 μA per scale division.

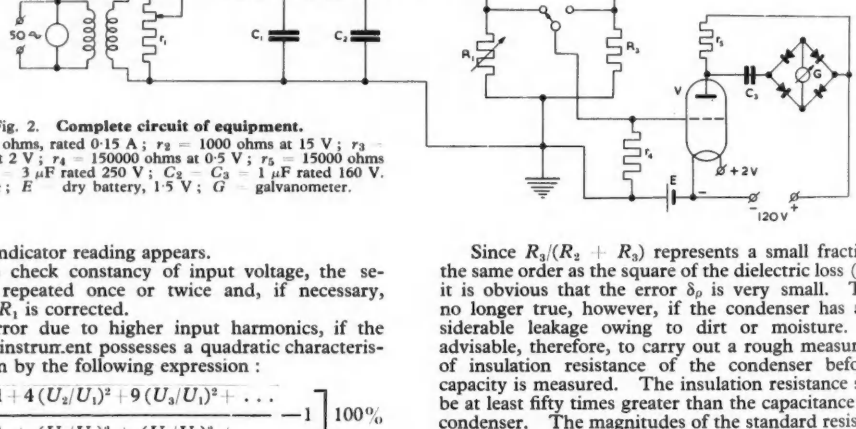


Fig. 2. **Complete circuit of equipment.**
r_1 = 5-6000 ohms, rated 0·15 A ; r_2 = 1000 ohms at 15 V ; r_3 = 3000 ohms at 2 V ; r_4 = 150000 ohms at 0·5 V ; r_5 = 15000 ohms at 1 V ; C_1 = 3 μF rated 250 V ; C_2 = C_3 = 1 μF rated 160 V. V Triode ; E dry battery, 1·5 V ; G galvanometer.

In the presence of rapid mains voltage fluctuations of the order of $\pm$ 1·5 per cent the probable error of the arithmetic mean of five measurements will only be $\delta_k = \pm$ 0·1 per cent.

The indicating circuit described above has a characteristic very near to the quadratic. Indicators with a linear characteristic are more sensitive to higher harmonics, and cannot therefore be recommended.

The input resistance of the amplifier valve should be at least one thousand times greater than the maximum value of R_1. To avoid the complication of special measurement of the input resistance, it is best to limit the maximum value of R_1 to 1,500 ohms. This recommendation is supported by the desire to avoid parasitic capacities encountered in resistances of much higher values.

A resistance r_4 of semi-conducting material is necessary to avoid transient impulses in the indicator, which would otherwise happen in the switch-over operation. When $R_1 > 150$ ohms, the influence of the shunt must be taken into consideration with an accuracy of $\pm$ 5 per cent.

It has been proved that power losses (leakage) in the condenser are responsible for an error :

$$\delta_\rho = \left(\frac{R_3}{R_2 + R_3} \tan\delta + 0{\cdot}5 \tan^2\delta \right) 100\% \quad .. \quad (3)$$

Since $R_3/(R_2 + R_3)$ represents a small fraction, of the same order as the square of the dielectric loss ($\tan\delta$), it is obvious that the error δ_ρ is very small. This is no longer true, however, if the condenser has a considerable leakage owing to dirt or moisture. It is advisable, therefore, to carry out a rough measurement of insulation resistance of the condenser before its capacity is measured. The insulation resistance should be at least fifty times greater than the capacitance of the condenser. The magnitudes of the standard resistances in the measuring circuit should be chosen in accordance with the following table :

Measured capacity μF	R_1 ohms	R_2 ohms	R_3 ohms
0·001–0·01	1,600–160	10,000	5
0·01–0·1	1,600–160	10,000	50
0·1–10	640–6·4	10,000	200

To improve the precision of these measurements, it is necessary to check repeatedly the frequency of the supply voltage.

Assuming that the error in the magnitudes of the constant resistances is $\pm$ 0·1 per cent, and that the error of the frequency measurement is $\delta_f = \pm$ 0·2 per cent, the probable total error of the measurement is

$$\Delta = \pm \sqrt{\delta_{R_1}^2 + \delta_{R_2}^2 + \delta_{R_3}^2 + \delta_f^2 + \delta_k^2} = \pm 0{\cdot}3\%$$

Experimental verification of the method presented here and its comparison with measurements obtained with a precision bridge has shown that the error is within $\pm$ 0·3 per cent.

The Oscillograph as a Null Indicator for A.C. Bridges

By G. TAMBURELLI. (From *Elettronica*, Vol. 1, No. 1, January-February, 1952, pp. 29-33, 19 illustrations.)

This article describes a method for balancing a bridge by means of only two operations and presents diagrams of arrangements suitable for practical applications.

THE bridge output voltage is amplified and applied to the vertical deflection plates of an oscillograph. The supply voltage is connected to the bridge input terminals and to a phase shifter, the output of which is applied to the horizontal plates of the oscillograph. Instead of an oscillograph, a moving coil type instrument with an appropriate circuit and a central zero position may be used.

In the unbalanced condition of the bridge, the two voltages applied to the oscillograph plates are generally out of phase so that the electron beam will describe an ellipse on the oscillograph screen. The unbalanced component which is in quadrature with the voltage of the phase shifter is cancelled out by giving a suitable value to the phase of the output voltage of the phase shifter. This reduces the ellipse on the screen to a straight line inclined at an angle relative to the horizontal axis. Then, by acting on the in-phase component, this straight line is made to rotate until it becomes horizontal. The bridge is then balanced.

Harmonics due to non-linear elements in the bridge or ripples in the supply voltage can be attenuated by using a selective amplifier tuned to the measuring frequency and do not prevent the balancing operation. Instead of a straight line, however, a simple Lissajous figure is obtained with the harmonics.

The input impedance of the amplifier must be high enough for it to take only a negligible amount of current from the bridge. The accuracy of the balancing depends on the amplifier gain ; however, with a high gain the value of the maximum unbalanced voltage which can be observed on the oscillograph screen is reduced so that, with a bridge having a considerable initial unbalance, it may be necessary to reduce the gain first and to increase it subsequently for a finer balancing adjustment. This additional adjustment can be avoided by using an amplifier circuit with a logarithmic response to the input voltage. For instance, with a moving coil instrument, oxide type rectifiers can be employed ; with an oscillograph, an automatic sensitivity control can be arranged, which acts energetically on the first stage only in order to avoid the introduction of harmonics due to the variable slope characteristic of the valve.

In regard to the valve shifter, as an appreciable amount of power is not required at the terminals, this unit can be a simple MacNamara bridge, with resistances R and capacitances C in opposite branches. By varying the resistances (or the capacitances) simultaneously in order to maintain these at equal values, the magnitude of the output voltage is kept constant, while its phase relative to that of the input voltage can be varied between 0 and 180 deg. when the resistances are varied from zero to infinity or the capacitances from infinity to zero.

BASIC THEORY AND PRACTICAL APPLICATIONS

(*A*) *Bridge with slight initial unbalance:*—We consider a bridge with a supply voltage applied to its terminals A and B, the output terminals being C and D. The impedances are denoted by Z_1, Z_2, Z_3 and Z_4 proceeding in the clockwise direction from A.

The unbalanced voltage is then

$$V_{CD} = V_{AB}\,(Z_1 Z_3 - Z_2 Z_4) / [(Z_1 + Z_2)\,(Z_3 + Z_4)] \quad (1)$$

With slight initial unbalance, the denominator $1/Y^2$ can be regarded as constant in comparison with the numerator, during the adjustment of a bridge parameter, so that we may write

$$V_{CD} = V_{AB}\,Y^2\,(Z_1 Z_3 - Z_2 Z_4). \quad .. \quad (2)$$

For instance, if R_1, the real part of $Z_1 = R_1 + j X_1$, is varied by ΔR_1 we obtain

$$V_{CD} + \Delta V_{CD} = V_{AB}\,Y^2\,[(R_1 + \Delta R_1 + j X_1)\,Z_3 - Z_2 Z_4]$$

so that

$$\Delta V_{CD} = V_{AB}\,Y^2\,Z_3\,\Delta R_1 \quad .. \quad .. \quad (2')$$

Furthermore, we have the approximate relation : $Z_1/Z_4 = Z_2/Z_3 = (Z_1 + Z_2)/(Z_3 + Z_4)$ from which $Z_3 + Z_4 = (Z_1 + Z_2)\,Z_3/Z_2$ and the substitution of this in eq. (2′) gives :—

$$\Delta V_{CD} = V_{AB}\,Z_2\,\Delta R_1/(Z_1 + Z_2)^2 \quad .. \quad (3)$$

This relation shows that the phase of V_{CD} relative to V_{AB} is that of $Z_2/(Z_1+Z_2)^2$ so that when R_1 is varied, the tip of the vector V_{CD} will move along a straight line inclined relatively to the horizontal vector V_{AB} by an angle corresponding to $Z_2/(Z_1 + Z_2)^2$ and not passing generally through the origin O. By acting on another bridge parameter, the phase of V_{CD} is made equal to that of the angle previously mentioned, that is, V_{CD} is brought along a straight line parallel to the previous one but passing through the origin, so that when R_1 is varied the voltage V_{CD} can be cancelled out along this line.

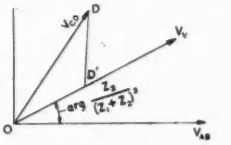


Fig. 1.
Vector diagram showing the two operations required for balancing.

The balancing is obtained as shown in Fig. 1. The tip of the vector V_{CD} is displaced from D to D' by a first adjustment which brings it into phase with the voltage V_V of the phase shifter. Then by varying R_1, $V_{CD'}$ is cancelled out along the straight line CD'.

(*B*) *Bridge with high initial unbalance:*—The previous considerations are no longer valid. The vector V_{CD}, with a magnitude much greater than that which has so far been considered, will move on circles which do not have their centres at the origin O. There are two families of circles, corresponding to the two variable parameters, and two of these circles pass through O. Their tangents at this point determine the directions of displacement of the tip D according to the previous analysis. The results previously obtained are therefore valid as long as the initial unbalance of the bridge is such that the points on the tangents are not very distant from the circles themselves. To apply the oscillograph method to the present case, it is necessary to reduce one of the two families of circles to a family of straight lines, one of which will pass through the origin and maintain its direction unchanged irrespective of the variations of other bridge parameters.

To examine this possibility it is necessary to consider again eq. (1) :

$$V_{CD} = V_{AB}\,Z_1/(Z_1 + Z_2) - V_{AB}\,Z_4/(Z_3 + Z_4).$$

When, for instance, the value of R_1 is varied, this alters only the first term in eq. (1). Therefore, to avoid changing the phase of V_{CD}, it is necessary to leave the phase of this term unchanged and the other term must have an equal phase. The latter condition can be fulfilled by varying first another parameter of the bridge.

To maintain a constant phase value for $Z_1/(Z_1 + Z_2)$

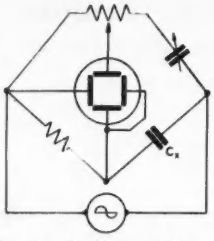


Fig. 2. **De Sauty bridge adjusted for balancing.**

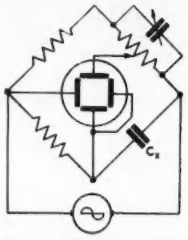


Fig. 3. **Wien bridge adjusted for balancing.**

when R_1 is varied, there are two possible solutions. The first is to make Z_1 and Z_2 have equal phases so that $Z_1/(Z_1 + Z_2)$ will have a phase angle always equal to zero. In this case, Z_1 and Z_2 must be ohmic resistances only. The phase shifter is then unnecessary and it is sufficient to apply to the horizontal axis all or part of the voltage applied to the bridge.

The second solution is to maintain constant the phase of Z_1 and of $Z_1 + Z_2$ by making Z_1 equal to R_1 and inserting a potentiometer in R_1 so as to increase the resistance of Z_2 by the amount corresponding to the decrease in resistance of Z_1. The phase shifter is then replaced by a second amplifier. The unknown impedance can be placed at Z_2 provided the voltage V_{AC} is applied to the horizontal axis. Instead of R_1 one can use an impedance with a potentiometer arrangement in parallel, although this may modify considerably the bridge characteristics. Fig. 2 and 3 show the applications of this system to a De Sauty bridge and a Wien bridge. No phase shifter units are used and the amplifiers are not indicated in the figures.

GERMANY

The Step Welding of Steel

By T. NORÉN. (From *Stahl und Eisen*, Vol. 72, No. 7, March 27, 1952, pp. 347-350, 5 illustrations.)

The step welding process compared with the method of gradient quenching for alloy steel hardening. The main advantage claimed is freedom from cracking when welding tool steels. The importance of the time-temperature transition diagram as a basis for welding specifications. The basic differences between welding by the gradient quench process and the step welding method and its modifications, and new possibilities of practical application. Experience from actual welding jobs.

FROM experience so far gained, it can be said that the step welding process lends itself particularly to the welding of tool steels. It was called "step welding" because the welding process, like gradient quench hardening, is based on the delayed transition of austenite within the temperature range of the formation of the intermediate structure. Two kinds of step welding, according to the choice of the welding temperature, will be described in regard to their basic assumptions and their possibilities of application, i.e., plain step welding and step quench welding.

The main advantage of the step welding process is the considerably improved resistance to cracking of the welded joints as compared with the usual welding methods using prior annealing of the parent metal. At the same time, the often difficult problem of choosing the correct hardening process for such steels after welding is also solved. It has been a special problem to obtain weld metal which required the same heat treatment for hardening as the parent metal itself. The hardening temperature of the parent material may be, say, only 850° C compared with, say, 1000° C for the welding alloy. The completed part, if hardened at 850° C, will not show the required hardness in the weld. If, however, it is hardened at 1000° C the parent metal will show increased brittleness due to overheating.

The basis for applying this process is given by the

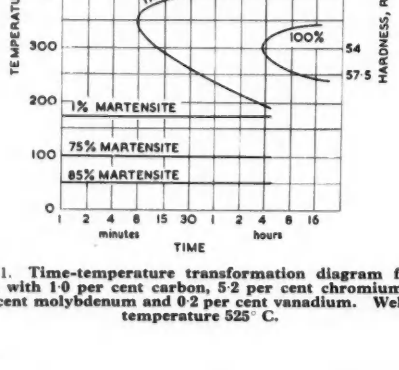


Fig. 1. **Time-temperature transformation diagram for a steel with 1·0 per cent carbon, 5·2 per cent chromium, 1·1 per cent molybdenum and 0·2 per cent vanadium. Welding temperature 525° C.**

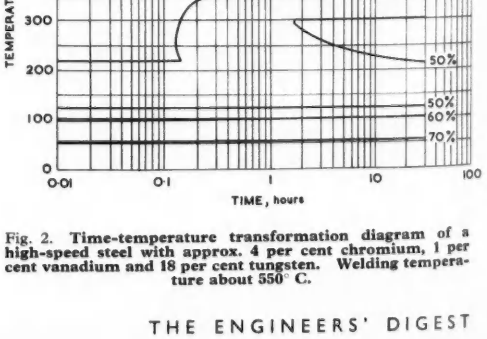


Fig. 2. **Time-temperature transformation diagram of a high-speed steel with approx. 4 per cent chromium, 1 per cent vanadium and 18 per cent tungsten. Welding temperature about 550° C.**

time-temperature transformation diagrams for the individual types of steel. These have been sufficiently described in literature[1], so that no further discussion seems to be necessary. These diagrams indicate the length of time and the temperature range required by individual steels for transformation from one structure to the other. A close comparison of the diagrams for the parent metal and the weld metal forms the basis for step welding.

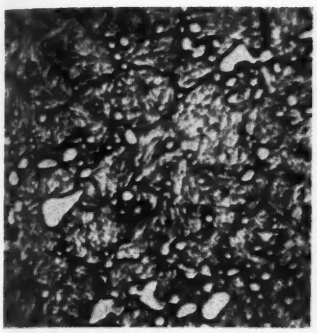


Fig. 3. Parent metal before welding.

Fig. 4. Parent metal after welding, at a distance 10 mm from the weld.

Fig. 5. Parent metal immediately adjacent to the weld.

Figs. 3 to 5. Microstructure of a high-speed steel with approx. 4 per cent chromium and 18 per cent tungsten, welded at 550° C by the gradient quench process. Magnification × 1200, etched by alcoholic nitric acid solution.

Fig. 1 gives an example of a steel containing 1·0 per cent carbon, 5·2 per cent chromium, 1·1 per cent molybdenum and 0·2 per cent vanadium. In this case, the suitable welding temperature would be about 525° C. The welding procedure will be as follows :

(1) The parent material is to be heated to its correct hardening temperature and kept at that temperature for the usual period.
(2) Then the parent material is to be cooled to that temperature which, from the time-temperature transformation diagram, shows a slow transformation of the austenite structure. Welding is to be carried out at this temperature, taking care that the temperature range necessary for the parent metal is not exceeded in either direction.
(3) After welding, the work-piece should be air-cooled to room temperature (about 20° C).
(4) Then follows tempering to rather low temperature, and
(5) dressing or machining of the weld.

A *modification* of the plain step welding method consists in welding in the temperature range of the formation of pearlite. After welding, the work-piece is kept in an annealing furnace at constant temperature until parent metal and weld metal are of completely pearlitic structure. As an example, it may be required to repair or to manufacture a tool of high-speed steel by depositing an especially hard alloy on the cutting edges. The work-piece is to be finished, not by grinding, but by machining. This can be achieved by the following procedure. After heating to its hardening temperature and cooling, the work-piece is welded at about 700° C, and kept at this temperature in a furnace for 10 to 12 hours until all the austenite has been transformed into pearlite. After air cooling, the machining can be carried out. Finally, the completed work-piece is hardened in the usual way. The difficult annealing of the tool steel is thus avoided.

The principles of plain step welding have been applied for a long time in the practice of *multiple layer deposit welding* of hard alloys. Many layers of a hard alloy are deposited by welding in such a way that each layer has been hardened. During welding, therefore, a temperature has to be maintained at which there is no danger of the austenite being transformed before work has been completed. If, instead, each layer of deposited alloy were allowed to cool down to room temperature before depositing the next layer, the individual layers would be tempered and softened by the heat effects of the successive layers. This explains why certain types of hard alloys are unsuitable for multiple layer deposit welding.

The above remarks may possibly produce the impression that the process of step welding is too difficult in its metallurgical aspects to be applied in the workshop. This is not so, as there is no need for the operative to know the metallurgy of the method. Simple and precise specifications of procedure must, however, be laid down. Experience has shown that the various processes of step welding are, in many cases, surprisingly easy to carry out.

As an example, Fig. 2 shows the time-temperature transformation diagram of a high-speed steel with about 4 per cent chromium, 1 per cent vanadium and 18 per cent tungsten. This steel was heated to 1250° C, cooled to 550° C and welded, then air-cooled to room temperature. Fig. 3 shows the microstructure of this steel before welding, Fig. 4 after welding at a distance of 10 mm from the weld, and Fig. 5 closely adjacent to the weld. The differences in microstructure are quite small and this is an indication of the quality of the weld and, thus, of the welding procedure.

Any kind of step welding is safest to carry out if furnaces are available which can be accurately regulated. Experience has shown, however, that, very often, primitive facilities will be sufficient. An acetylene-hydrogen torch can be used for heating the work-piece to the required hardening temperature. The tarnish colours serve as an indicator for the temperature, and a magnet can be used to show the sudden decrease of magnetism indicating the transformation of the steel to the non-magnetic austenitic structure.

The quality of the welded joint is essentially dependent on maintaining the accurate temperature throughout the welding operations, especially if these occupy a longer period. It would be wrong to allow an increase of the predetermined welding temperature from, say, 500° C to 600° C or 700° C, because this may lead to a partial or complete transformation of the austenite into pearlite. In principle, however, this requirement does not add to the difficulties of the step welding method. On the other hand, it is a notable

(*Concluded overleaf.*)

[1] e.g., Atlas of Isothermal Transformation Diagrams of B.S. En-Steels, London, 1949, 63 pp., Special Report No. 40, Iron & Steel Institute.

SWITZERLAND

Machining of Bevel Ring Gears on Copying Lathes

INGENIOUS tooling-up of machine tools frequently increase their range of application and reduces machining times. The need for this is particularly apparent at the present time when supplies of certain types of machine tools are very limited or even non-existent, and other machines have to be substituted. It is often found that the "substitute" method is as efficient as the one based on a machine tool originally considered ideal for the job. A typical example of this is the machining of rear axle bevel ring gears on a Georg Fischer copying lathe. Originally, this component was to be machined on a multi-spindle machine and it was stipulated that no operation must exceed 1·8 minutes. Fig. 1 shows a section of the finished ring, indicating the metal which is to be removed. It is, of course, not feasible to produce the drilled hole on the lathe, and this operation will therefore have to be carried out on another machine.

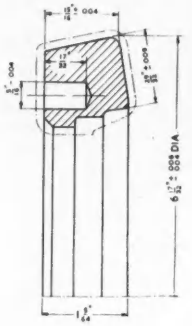


Fig. 1 (left)

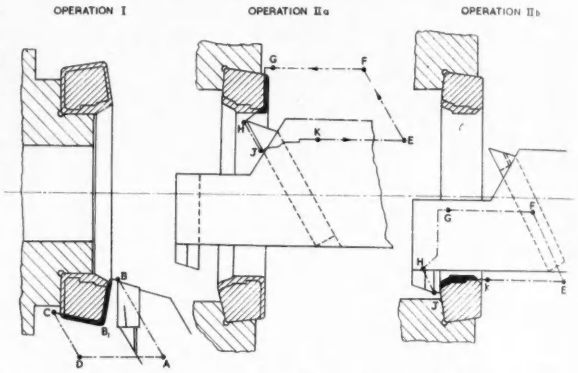


Fig. 2 (right)

The gear is made of a case-hardening Cr Mn steel, annealed and heat-treated to 47-54 tsi, and the machining allowance after forging is limited to 3/32 in. to 5/32 in. all over.

Two operations are required, as the ring has to be machined all over and must therefore be chucked twice. The equipment required for both operations consists of two GF Copying Lathes type KDM, power-operated chucks with special jaws, boring bar and tool holders, copying tools and templates and tracers. The operations are illustrated in Fig. 2, Table I summarising the individual stages and giving the build-up of floor-to-floor times. It can be seen that the times are within the specified requirements. It is also noteworthy that the initial investment for the two copying lathes is approximately half that required for the multi-spindle machine.

TABLE I.

First operation on Machine 1.		
WORK	Estimated time, minutes	
	Handling	Cutting
(1) Mount work on internal chuck, start spindle (224 rpm, 380 fpm) ..	0·18	
(2) Tool approach from A to B ..	0·1	
(3) Copy turn *B* to *C*. Feeds: *B*-B_1 0·015 in./rev. B_1-*C* 0·0126 in./rev.	—	0·85
(4) Automatic return of tool from *C* to *D*, and return to starting position *A*. Stop spindle, remove work. ..	0·12	
TOTAL ..	0·4	0·85
Floor-to-floor time .. 1·25 mins.		
Second operation on Machine 2.		
A. (1) Mount work on 3-jaw chuck, start spindle (224 rpm, 380 fpm)	0·18	
(2) Upper tool approach from *E* to *F*	0·1	
(3) Rapid traverse from *F* to *G* (100 ipm)	0·05	
(4) Copy turn *G* to *H* from upper template. Feeds: Face 0·02 in./rev., chamfer 0·01 in./rev.	—	0·45
B. (5) Tool approach from *H* to *J*		
(6) Copy turn *I* to *K* from lower template	—	0·65
(7) Rapid traverse return. Stop spindle, remove work	0·12	
TOTAL ..	0·45	1·1
Floor-to-floor time .. 1·55 mins.		

Summary

	Operation I	Operation II
Handling time	0·4	0·45
Cutting time	0·85	1·1
Floor-to-floor time	1·25	1·55
Allowance 15%	0·18	0·23
TOTAL	1·43 mins.	1·78 mins.

THE STEP WELDING OF STEELS

(Concluded from previous page)

advantage of this method may be repeated after removing any unsatisfactory welds obtained under faulty conditions.

Such *repeated welding* has many times been successfully carried out in the course of these tests, with parent materials which are difficult to machine. As an example, the repair of a milling tool may be mentioned[2]. This tool, made of high-speed steel, was repaired by the step welding process, but both the parent metal and the weld metal were afterwards found to be too soft. A microstructure specimen prepared from one of the soft teeth was examined. It showed that the welding operations, extended over a period of about 4 hours, together with the high temperature of about 700° C during welding, had led to a partial transformation of the austenite into pearlite. In a second attempt, the tool was again heated to its hardening temperature and the welding repeated at 500° C. After final cooling in still air, the tool was found to be satisfactorily hardened all over, including the teeth, which had previously been too soft and had to be welded again.

SUMMARY

This new process, called "step welding," is based on the principles of gradient hardening and is particularly applied to the welding of alloy tool steels. Even high-quality tool steels which call for difficult hardening methods can now be welded without risk of cracking. The structure of parent metal and weld can be maintained without being affected by the welding process.

[2] T. Norén and S. Lundin, Application of Hard Surfacing, *Svetsaren*, Göteborg, 16 (1951), No. 1, pp. 1-12.

Lathe Tools with Varying Cutting Angle

By E. I. LYUBOMIRSKY. (From *Stanki i Instrument*, No. 8, 1951, pp. 19-21, 9 illustrations.)

The author proposes a varying cutting angle and front rake for lathe tools. In the light of our knowledge on chip formation, this geometry of the cutting edge should reduce cutting force fluctuations. Particular benefits are obtainable in intermittent cutting. Methods of grinding to obtain proposed geometry are discussed.

THE process of chip formation varies according to the metal of the machined component. In the cutting of cast iron, the chip forms through a series of shear failures, and this process is accompanied by large fluctuations of the cutting force. In the cutting of steels, the chip forms through slipping or by fusion. The fluctuations of the cutting effort are less pronounced. Oscillations of the cutting force are a source of forced vibrations of the component, the machine, and the tool. The cutting edge of a high-speed steel tool can withstand considerable vibrations. Therefore, such tools perform well in the machining of both cast iron and steel. Hard metals are more brittle, and only the tougher types of hard metal are used for the machining of cast iron.

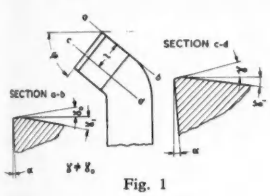


Fig. 1

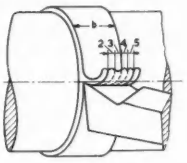


Fig. 2

A method of reducing the fluctuations of the cutting force lies in the design of the tool. It is claimed that a cutting tool with a varying cutting angle (or a varying front rake), along the cutting edge, reduces the fluctuations of the cutting force.

The influence of the cutting angle on the formation of the chip is known. The main effect is a change in the nature and geometry of shearing and slipping in relation to the cutting edge. In Fig. 2, turning with a tool of varying cutting angle is shown diagrammatically. It may be assumed that each elementary width of the chip is associated with a constant cutting angle. In Fig. 3, a hypothetical fluctuating force is shown for each element of width. The effect of varying cutting angle is that fluctuations take place with a phase displacement. With a correctly chosen geometry we may achieve a resultant cutting force diagram shown by graph 1 in Fig. 3. Thus, under otherwise identical conditions, the fluctuations of the cutting force can be greatly reduced by means of a varying cutting angle, and varying front rake. In this way, the harder and more brittle hard metals can also be used for the machining of cast iron, and the allowable cutting speeds can be considerably increased.

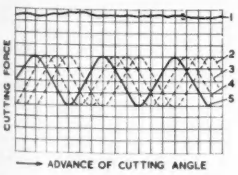


Fig. 3

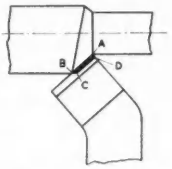


Fig. 4

The benefit from varying cutting angles will be most pronounced in turning work with a variable section of cut, and where an impact occurs in machining. In such conditions, the advantage of a negative rake is known. It is also known that when machining a component which demands a sudden engagement of the cutting edge, it is advantageous to arrange for the first contact to occur at point C (Fig. 4). Figure 5 shows the geometry of a tool suitable for impact turning, embodying the principles of this article.

Some workshop trials have proved the advantages of a varying cutting angle. Under identical conditions, machining times between regrinds have been increased from 10 to 45 minutes. In one particularly trying case of intermittent cutting, owing to longitudinal gaps in the component, a tool of normal geometry proved useless. The tool with a varying cutting angle yielded 30 minutes of satisfactory machining between regrinds.

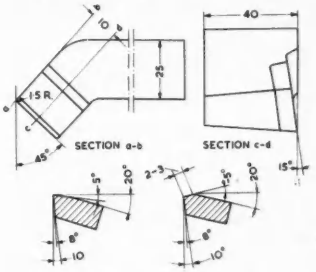


Fig. 5

It is seen in Fig. 1 that the characteristic geometry of the cutting edge with varying cutting angle is represented by the quantity

$$k = (\gamma - \gamma_0)/l \qquad .. \qquad .. \qquad (1)$$

k determines the change of front rake (γ) per unit length of the cutting edge. The increment of change of the front rake over the width of cut is given by the expression

$$A = kb = \frac{kt}{\sin\varphi} \text{ (in degrees)} \qquad .. \qquad (2)$$

where t = the depth of cut, and φ = the angle of the cutting edge against the direction of advance of the tool. Equation (2) shows that with the same depth of cut it is possible to obtain a larger increment of front rake by varying the angle φ. As we have seen, the front rake can vary in magnitude and sign along the cutting edge. Two variants are possible.

1. Front rake increases towards tip of tool.
2. Front rake decreases towards tip of tool.

Semi-finish and finish machining in a continuous and uniform cut should be done with tools of the second variant. In this case, it is also best to finish with a negative rake at the tip of the tool.

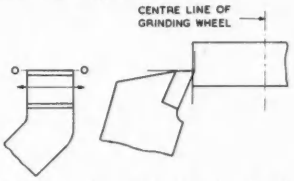


Fig. 6

In machining with a changing depth of cut or with intermittent engagement, the first variant of tool design should be employed, because the most highly loaded point of the cutting edge is that which makes contact with the outside diameter of the turned component.

In Fig. 6 the method of grinding cutting tools in

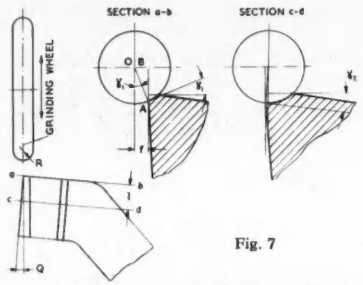


Fig. 7

accordance with these proposals is shown diagrammatically. The tool must be clamped in the fixture in such a way that it can be turned about an axis through the cutting edge. Clearly, swinging the tool around the axis *O-O*, and simultaneous traversing in the direction of the arrows, will produce along the cutting edge a land which gives a varying front rake. Another method of grinding to achieve a varying front rake is shown in Fig. 7. The magnitude of the front rake angle γ_1 is derived from the equation $\sin \gamma_1 = f/R$ and the magnitude of angle Q is obtained from the equation

$$\tan Q = \frac{R}{l} (\sin \gamma_1 - \sin \gamma_2)$$

where γ_2 is the given front rake angle at a distance l from the tip of the tool The disadvantage of this method is its dependence on the accuracy of the rounded cross-section of the grinding wheel.

GERMANY

Temperature Measurements in Wire Drawing with a Wire-Die Thermocouple

By W. LUEG. (From *Stahl und Eisen*, Vol. 71, No. 22, October 25, 1951, pp. 1140-1147, 12 illustrations.)

DRAWING trials were carried out on a patented steel wire and a low-carbon wire rod under different working conditions. The temperature in the die was recorded by a thermocouple formed by the hard metal of the die and the drawn wire. The results show that the wire-die thermocouple is suitable for obtaining a clearer picture of the temperature relationships in the drawing process. Only the average value of the temperature distribution in the die can be recorded. The influence of the working conditions on the temperature recording was, fundamentally, what was expected. The values obtained by the method, however, are not sufficient in themselves either to enable a conclusive opinion to be formed as to the quantitative values of the maximum temperatures obtained or to judge the quality of the drawing lubricant.

The question of temperature conditions in the die and the wire is important for a complete study of the drawing process, drawing speeds, choice of lubricant, and other operational conditions.

Previous methods for measuring the temperature of the wire leaving the zone of deformation included the use of a " flying thermocouple," but only at low drawing speeds. Simultaneously, the heat absorption of the die was measured by a calorimeter, so that, for the drawing of short lengths, a heat balance could be established. It was shown that 13 to 28 per cent of the heat produced by deformation and friction was transferred to the die. The wire temperature when leaving the die was between 100 and 200° C.

The author's apparatus was an electric horizontal drum 400 mm (15¾ in.) in diameter, as shown in Fig. 1. The steel die case with a hard metal insert was grooved at the in-going side in such a way that the bearing of the hard metal core was bared for a short distance. One end of a 150 mm (5⅞ in.) long hard metal rod was fitted into the slit. By making an electrical connection between the wire at the exit of the die and the free end of the hard metal rod and a mirror galvanometer, a thermocouple circuit is obtained in which the point of contact between wire and die forms the hot junction, and the contact of wire and hard metal rod the cold junction.

A patented 0·6 per cent carbon steel of 4 mm diameter with a tensile strength of 100 kg/mm² (63 tsi) was used alongside a 5 mm rod of 23-tsi steel. Drawing speeds were 0·06 or 0·15 m/sec. The wires were pickled before drawing. Rape oil or a special drawing lubricant were used. Only a limited length of wire could be drawn in each experiment because the drum of the

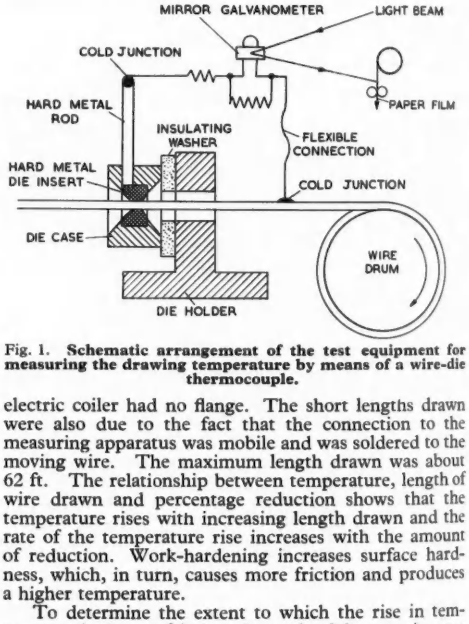


Fig. 1. Schematic arrangement of the test equipment for measuring the drawing temperature by means of a wire-die thermocouple.

electric coiler had no flange. The short lengths drawn were also due to the fact that the connection to the measuring apparatus was mobile and was soldered to the moving wire. The maximum length drawn was about 62 ft. The relationship between temperature, length of wire drawn and percentage reduction shows that the temperature rises with increasing length drawn and the rate of the temperature rise increases with the amount of reduction. Work-hardening increases surface hardness, which, in turn, causes more friction and produces a higher temperature.

To determine the extent to which the rise in temperature is due to friction alone, the 2·8 mm wire was drawn through the die without reduction. The rise in temperature due to friction only was a third of that resulting from a 23 per cent reduction.

Drawing wire and rod with increasing reductions and back-pull showed clearly the effects of tensioning on the temperature conditions of the die. As could be expected, the temperature was reduced as the amount of back-pull was increased. Electrical conductivity of the drawing lubricants influences the temperature recorded, since a complete film has a great resistance to the flow of current in the temperature-recording circuit.

With patented steel wire, the effect of work-hardening becomes evident when three separate drawing operations are performed on the same wire.

CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns, are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

ABRASIVES

The Grinding of Case-Hardened and Nitrided Steels with Sintered Corundum Wheels

By M. S. RAKHMAROVA. (From *Stanki i Instrument, Russia*, No. 10, 1951, pp. 14-16, 7 illustrations.)

MODERN grinding must meet the combined requirements of precision, surface smoothness, freedom from cracks and high productivity. Sintered corundum is a form of aluminium oxide, which differs from the ordinary corundum made in electric furnaces and has properties which enable it to meet the above requirements more adequately.

Electrically produced corundum consists of grains which are polycrystalline aggregates. Such grains have few sharp edges and corners. When crushed, corundum grains split along crystal boundaries. On the other hand, sintered corundum grains are single crystals which possess a large number of sharp cutting edges. They split along crystallographic surfaces, which again produce sharp edges.

Furthermore, ordinary corundum grains often have voids and cracks, which reduce their strength. Sintered corundum grains have fewer imperfections. The micro-hardness of sintered corundum grains is substantially equal to that of ordinary corundum grains, and is about 2,160 kg/mm².

The production capacities of different grinding wheels were compared by measuring the volume of metal removed per minute; the volume of wheel wear; the ratio of the two volumes, which is taken as the specific productivity; and the endurance, defined as the time between dressings. Sintered corundum wheels have a specific productivity equal to that of silicon carbide (" carborundum ") wheels, and exceeding the productivity of ordinary corundum by 18-20 per cent in the grinding of nitrided steel. With case-hardened steel the equivalent improvement is 8-12 per cent. The grinding operation used for comparison was the external cylindrical grinding with longitudinal traverse. The peripheral velocity of the wheel was 30 m/sec and that of the component 20 m/min. The longitudinal feed was 0·3 of the width of the wheel per revolution of the component, and the depth of cut was 0·01 mm per double stroke.

The radial forces between the grinding wheel and the component were measured. Sintered corundum wheels have the smallest radial force of any, revealing the easier penetration of the sharp edges of its grains.

Microscopic examination of etched sections has shown a superior quality of surface produced by sintered corundum wheels. With case-hardened steels, the depth of the softened layer which results from grinding is considerably smaller when sintered corundum wheels are used.

INDUSTRIAL FURNACES

Molybdenum-Wound Hydrogen Atmosphere Furnaces

By W. P. KEITH. (From *American Ceramic Society Bulletin, U.S.A.*, March, 1952, pp. 76-78, 4 illustrations.)

MOLYBDENUM-WOUND hydrogen atmosphere furnaces have become useful and necessary tools for both industry and research. For the manufacture of carbide tools and radio tubes, for wire drawing, metal sintering, brazing heat treating, and research, this furnace has found wide use. The necessity of a reducing and non-carbonizing atmosphere, however, somewhat restricts the work these furnaces may do.

Although most of these furnaces are used only up to about 1650° C, some are in successful operation to temperatures as high as 1900° C. For high temperatures such as these, proper design, construction, and operation are of utmost importance.

The construction of these types of furnaces is best left to the professional furnace builders who, through engineering skill and practical experience, have developed practical and successful furnace designs. However, commercial furnaces often are not available for certain requirements, so that a special furnace must be constructed. It is to those who must build their own furnaces that the suggestions in this article are offered. With reasonable care, judgment, and observation of a few principles, it is possible to build a furnace to operate quite successfully at temperatures up to at least 1650° C.

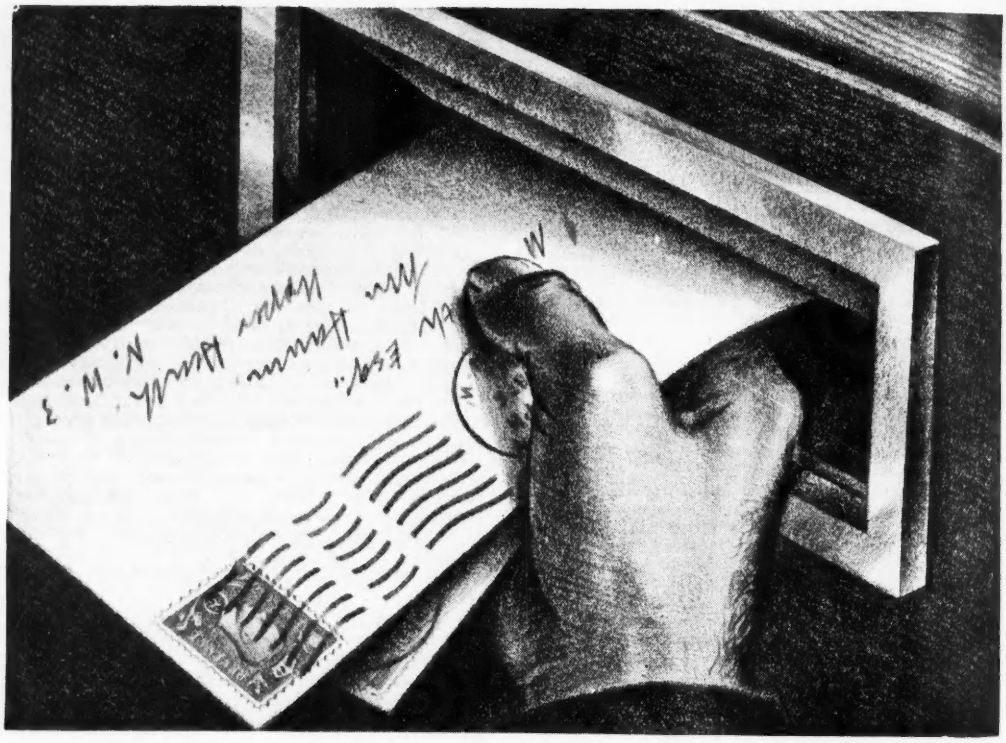
METALLURGICAL ENGINEERING

Investigation into W-Cr-rich W-Cr-Ni alloys

By H. BÜCKLE. (From *La Recherche Aeronautique, France*, No. 24, November-December, 1951, pp. 49-55, 19 illustrations.)

THE new development of jets and gas turbines with their high combustion temperatures increasingly calls for refractory sintered metal alloys which, though already in practical use, have not yet received systematic theoretical attention. The author presents a metallographic and mechanical investigation into alloys of the ternary W-Cr-Ni diagram with specimens prepared by sintering at 1500 to 1900° C in the presence of a liquid phase, a process giving products entirely free of pores. The alloys investigated contained up to 30 per cent Cr and up to 6 per cent Ni. Metallographic and mechanical examination shows generally the presence of W-rich hard α-crystals (650 kg/mm² Hanemann micro-hardness) in a softer Ni-rich matrix (γ-phase, 360 kg/mm²). However, the smaller the Ni-content, the harder the γ-phase, and in an alloy with only 2 per cent Ni and 8 per cent Cr, the α-and γ-phases are equally hard (800 kg/mm²). The hardness figures given are mean values and obviously vary widely with sintering conditions and heat treatment, so that a certain technical control of the mechanical properties is possible. Specimens with a soft γ-matrix show a ductile fracture, while those with a hard matrix break in brittle fashion. For a closer study of the Ni-rich γ-phase, specimens with 45 and 55 per cent Ni, 5 per cent Cr, remainder tungsten, were cast and heat treated, i.e., homogenised 4 hours at 1200° C, water-quenched, annealed first for 5 hours and then for 300 hours at 800° C, and observed at all stages of the treatment. A tungsten precipitation on quenching is followed by a slow ageing process of an as yet undefined nature, with increasing precipitation as annealing proceeds and a Brinell hardness mounting from 280 (as cast) to a fairly constant value of about 420 reached after 150 hours.

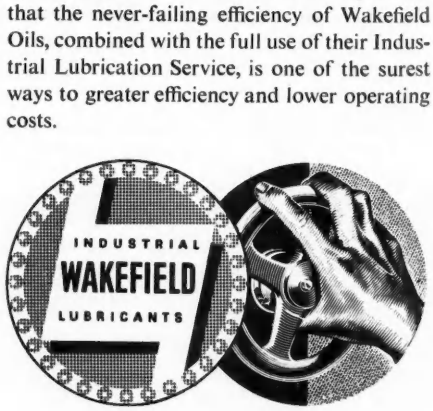
The technical importance of these heat-resisting



Efficiency that you take for granted . . .

The postman's double-knock and the plop of the letter on the front door mat are the end results of a long train of events. Sorters, mail vans and mail trains running to split-second schedule, robot operated underground railways, together with all the experimental work post office engineers undertake in a search for greater efficiency . . . all these are part of your early morning delivery . . . and all you take for granted.

Wakefield Industrial Lubricants are the end results of a long train of events. Perpetual research into every aspect of lubrication, unceasing vigilance at every stage of manufacture, 50 years' experience in producing the world's finest oils . . . all these are taken for granted by the engineer who knows from experience that the never-failing efficiency of Wakefield Oils, combined with the full use of their Industrial Lubrication Service, is one of the surest ways to greater efficiency and lower operating costs.



C. C. WAKEFIELD & CO. LTD. · GROSVENOR STREET · LONDON · W.1

alloys lies in the fact that non-porous components can be obtained by sintering in the presence of a liquid phase. Isothermal sections and an isometric view of the ternary equilibrium diagram show the range of alloys best suited to this process. By various ageing heat treatments, the character of the γ-matrix, and hence the mechanical properties of the sintered component, can be changed within wide limits, an aspect which merits closer investigation with a view to practical application.

METALS CORROSION

The Mechanism of Scale Formation on Iron at High Temperature

By B. W. DUNNINGTON, F. H. BECK and M. G. FONTANA. (From *Corrosion, U.S.A.*, Vol. 8, No. 1, January, 1952, pp. 2-13, 24 illustrations.)

A NEW mechanism of high temperature oxidation of iron is proposed. Diffusion of lattice vacancies in the iron is shown to influence the type of oxide that forms. It was found that with thin specimens an adherent film grew on one side and a loose film on the other. The adherent film followed the parabolic law. The loose film grew in a pseudo-linear manner. The formation of these two types of films is shown to be necessary from consideration of diffusion of iron through the metal and oxide lattices. Applying the same principles to large specimens, it is shown that a different kind of oxide layer forms, which was observed by Pfeil.

Photographs of magnetite slowly cooled from a high temperature indicate that a plate-like precipitate of Fe_2O_3 forms on the (111) planes of the magnetite.

A brief study was made of blistering. It is demonstrated that superficial blisters form on heating in air, and photographs show the later positions of the blisters as the oxide layers grow thicker.

RARE METALS AND ELEMENTS

Properties of Molybdenum Made by Arc Casting and Powder Metallurgy

By J. H. BECHTOLD and H. SCOTT. (From *Metal Progress, U.S.A.*, Vol. 61, No. 4, April, 1952, pp. 82-88, 11 illustrations.)

BILLETS of arc-cast and powder metallurgy molybdenum were prepared in the fully annealed and completely recrystallized condition. Tests showed little difference between arc-cast and powder metallurgy varieties in tensile properties over a range of temperatures above and below atmospheric, or in creep strength at 1600° F.

The cold brittleness of molybdenum was found to be associated with a well-defined transition from ductile to brittle fracture on a tensile test at a temperature only slightly below atmospheric. The brittle condition is characterized by a cleavage-type fracture such as occurs in iron near liquid air temperatures. Above the transition temperature, ductility is quite high.

Influence of stress distribution on the transition temperature was studied, using a notched tensile specimen with a theoretical stress concentration factor of 3·1. This condition raised the transition temperature to 257° F (125° C). The occurrence of this transition near room temperature and the pronounced influence of many factors call for meticulous control of fabrication for maximum cold ductility. Lowering of the transition temperature by alloying may be possible, as it is in iron, by the addition of a correct percentage of nickel.

The creep and rupture strength of molybdenum in the fine-grained annealed condition is high relative to other pure metals used for high-temperature alloys, and is superior to the best of the conventional alloys above 1650° F. Undoubtedly, this property can be considerably improved by alloying and possibly some degree of atmospheric oxidation resistance could be conferred as well, with the retention of a reasonable amount of hot ductility.

None of the tests showed any significant difference between arc-cast and powder metallurgy molybdenum in a comparable structural condition, although there are considerable differences in their hot working characteristics. Differences in carbon, nitrogen and oxygen content may be responsible for the upper and lower yield points observed in both materials. Material of extremely high purity will have to be prepared and tested to answer the questions raised by these observations.

WELDING

Automatic Welding with Contact Electrodes

By W. P. VAN DEN BLINK, H. BIENFAIT and J. A. VAN BERGEN. (From *Philips Technical Review, Holland*, Vol. 13, No. 9, March, 1952, pp. 247-253, 9 illustrations.)

SINCE contact welding electrodes allow of touch-welding, the welder is relieved of the task of "holding the arc," this being done, as it were, automatically. Also, the forward travel of the rod and the change-over from one electrode to the next can be carried out automatically, so that welds of any length can be made entirely automatically. For this purpose Philips have developed the Contact automatic welder. This consists of a "welding head" fitted with an oblique bar sliding in its own longitudinal direction and with the welding electrode clamped to its lower end at a given angle. The weight of the bar presses the tip of the electrode onto the workpiece and as the electrode melts down it is carried along parallel to itself. The rate of travel (and thus the thickness of the weld) is adjusted by varying the angles at which the bar and the electrode are set. A series of such welding heads is mounted at appropriate intervals along a rail above the workpiece, and each electrode comes to rest at the point where its bead begins. Each electrode takes over the arc from the previous one automatically as soon as the latter is consumed, the preceding electrode holder then being automatically retracted by means of an electromagnet in the head. In this way welding can be done in mass production with unskilled personnel, while still obtaining very good and uniform welds. The joints between the beads are scarcely perceptible.

Hard Facing for Impact

By H. S. AVERY. (From *The Welding Journal, U.S.A.*, Vol. 31, No. 2, February, 1952, pp. 116-145, 41 illustrations.)

WEAR, defined as deterioration due to use, is caused primarily by mechanical, chemical and thermal factors. The mechanical factors operate through stress, and impact is one of the important stress producers.

Hard facing, which is one of the important techniques for combating wear, can provide effective protection against deterioration from impact provided the alloys are properly selected and used. The most appropriate hard-facing materials for such service are martensitic irons, martensitic steels, and austenitic steels, which are considered suitable for light, medium and heavy impact, respectively.

Static and dynamic compression testing are described together with data for important hard-facing alloys, while the importance of avoiding tension is stressed. Critical limitations of impact energy and velocity are suggested to minimise structural damage and to help in alloy selection.

The three hard-facing alloy types are described in some detail to guide the engineer in their selection. A few representative applications are given and the advantage of composite structures in wear control is shown. This paper is intended to help engineers to cope with the problems of industrial wear and includes some pertinent data on abrasion.

Some propellers don't know their own strength

Only the best is good enough for whaling ships where complete reliability coupled with strength to resist abrasion by floating ice are of paramount importance. Clyde alloy stainless steel propellers have been meeting these arduous conditions for many years with complete success. Stainless Steel, with its excellent mechanical properties and high resistance to corrosion offers a combination of properties unmatched by other alloys. Our advisory services are at your disposal

CLYDE ALLOY

STAINLESS STEEL

PROPELLERS

THE CLYDE ALLOY STEEL CO. LTD. MOTHERWELL.

Telephone: MOTHERWELL 1051 *Telegrams:* "CLYDALL MOTHERWELL"

THE HANOVER TECHNICAL FAIR

The 1952 Technical Fair in Hanover, Germany, which took place from April 27th to May 6th, extended over an area of nearly 2 million sq. ft., and occupied even more space than last year's exhibition. Owing to the fact that machine tool manufacturers will show their products in the 2nd European Machine Tool Exhibition to be held next September, also in Hanover, considerably more space could be allotted to other sections of German industry. In the 22 Halls and in the open-air space, well over 2,000 exhibitors displayed a large variety of products, ranging from a heavy locomotive weighing 123 tons to a miniature ball bearing, less than $\frac{1}{4}$-inch in diameter and weighing as little as 0·5 gram. Thus, the Fair, in addition to its function as a market, afforded an excellent survey of present-day industrial trends and developments in Germany.

It is not possible, within the framework of a short review, to do justice even to a small selection of the many products displayed. Although an attempt has been made to deal in these pages with products which are likely to interest our readers, the few items described in the following had, to a certain extent, to be selected at random rather than on merit.

Among the large variety of hoisting equipment shown at the Fair, a ship's winch manufactured by MASCHINENFABRIK WILLI BAENSCH, Hamburg, was of particular interest. This compact machine, illustrated in Fig. 1, is characterised by its low weight and small space requirements, nearly half those of conventional winches. The principal advantages of this new winch, however, lies in its electro-hydraulic drive, which is responsible for its excellent speed control characteristics. Hoisting and lowering speeds are steplessly variable within very wide ranges, as can be seen from Fig. 2. Speed control is effected by the operation of a single lever, which is swung out of the zero position either to the right (hoisting) or to the left (lowering). The angle through which this lever is swung is proportional to the speed with which the load is hoisted or lowered. When the lever is returned to the zero position, the load is automatically arrested, so that complete control of all load movements is centred in this single lever. The hydraulic gear automatically protects the motor from overloading. If the electricity supply fails, the load is stopped, but even then it can be lowered steplessly as if no failure had occurred.

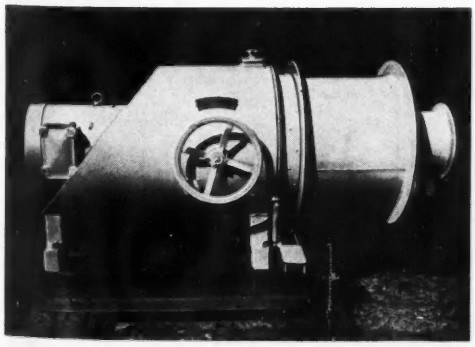


Fig. 1

Owing to the very wide speed control range, which is shown graphically in Fig. 2 for a 5-ton winch, and to the large acceleration made possible by the constantly running electric motor coupled to the hydraulic gear, it is possible considerably to reduce the electrical power requirements. The winch constitutes a self-contained

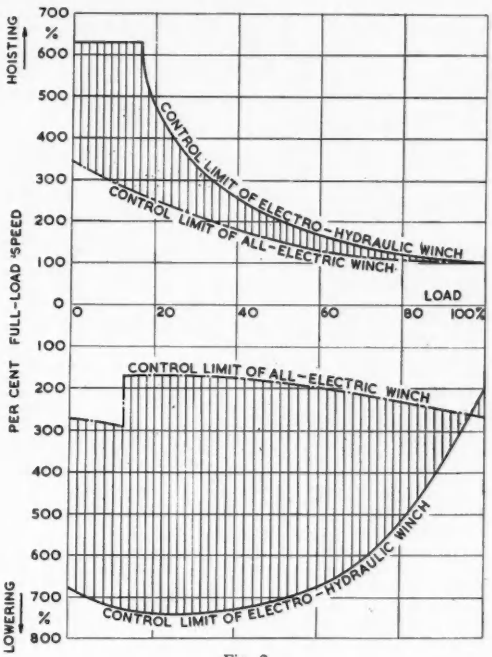


Fig. 2

The shaded area represents the increase in control range.

electro-hydraulic unit, so that there is purely an electrical connection between the ship's generating plant and each individual winch, i.e., no hydraulic pipe lines are necessary. The winch motor can be d.c. or a.c. as required, but the electric motor could also be replaced by a diesel engine or steam motor.

The winch is sturdily built with a rigid cylindrical frame, thus ensuring good alignment of all moving parts independently of any deflection of the ship's structure.

An interesting new exhibit was the chipless broach for sizing, manufactured by Messrs. J. SCHWAHLEN, of Solingen. These broaches, which are produced in sizes ranging from 0·4 in. upwards, compress about 0·004 in. to 0·008 in. of the material in the bore on being forced through. The total effort is distributed over ten to twenty rings. On individual small holes, the thrust required to force the broach through the bore can be supplied by a hydraulic hammer. For multiple operation or large bores, hydraulic or other presses can be employed. In comparison to existing processes, the time required for this new method

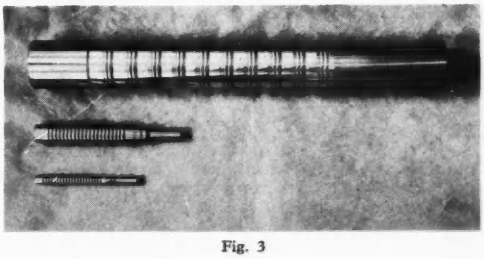
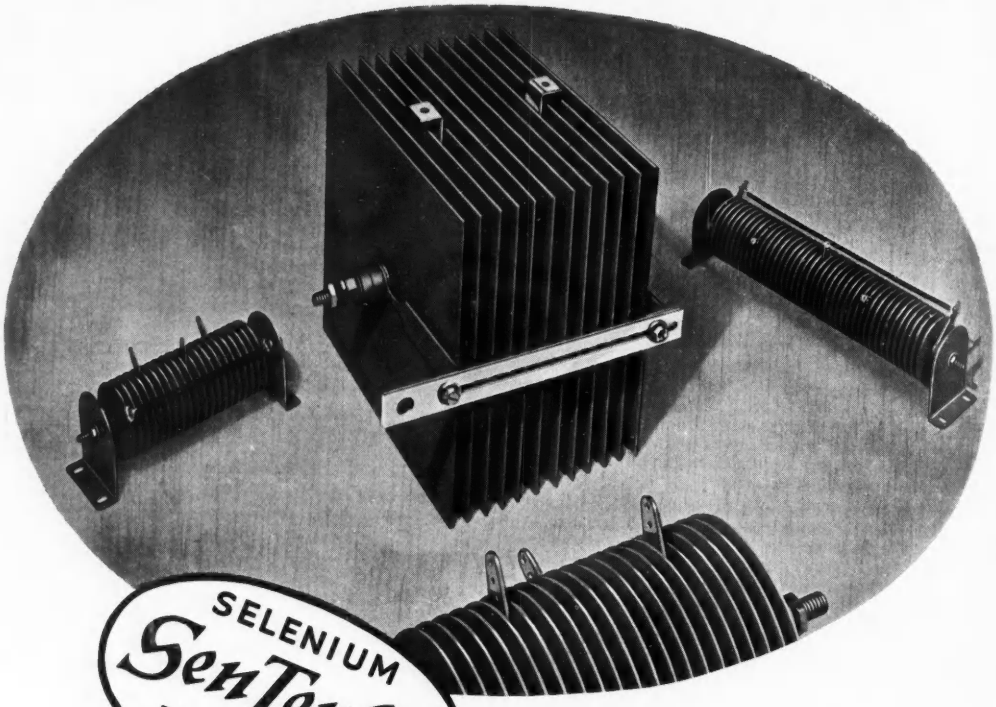


Fig. 3



SELENIUM
SenTerCel
RECTIFIERS
REGISTERED TRADE MARK

rectifiers

for industry

Please write for leaflet ***F/SRT6***

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, W.C.2

RECTIFIER DIVISION: Warwick Road, Boreham Wood, Hertfordshire

Telephone: Elstree 2401. Telegrams: 'SenTerCel, Borehamwood'

is very short and the resulting bore can be held to very fine tolerances. The polished surface of the bore is work-hardened during the operation, and its strength is increased by some 40 per cent over its normal strength in the original condition. The provision of a pilot on the front of the tool ensures straight guidance, waviness in the bore, as is sometimes experienced when forcing hardened balls through a bore, being completely avoided. Prior to use, the broach has to be well covered with oil, which remains on it throughout the operation. This is achieved by the provision of oil-retaining grooves between the individual rings.

The process has been thoroughly investigated and tested by three reputable German engineering firms, small broaches below 2·4 in. and large broaches in excess of this diameter being used. In one case, it was found that a finished bore in 27-tsi steel had a tensile strength of 38-45 tsi. No measurable wear on the hard-chromed surface of the broach rings was detected after a life of 400 components. The length of the bore was 9½ in., and tight-fitting bolts, which previously had to be fitted individually, could now be used on an interchangeable basis. The process should be of interest for all engineering production concerned with close tolerances on through-holes and bores.

The number of welding machines and welding equipment on show was not very large, probably because welding machines will also be displayed at the 2nd European Machine Tool Exhibition. However, the electronic flame cutting machine ULTRAREX, manufactured by KJELLBERG-EBERLE, Frankfurt/Main, should be of interest. This machine is equipped with a

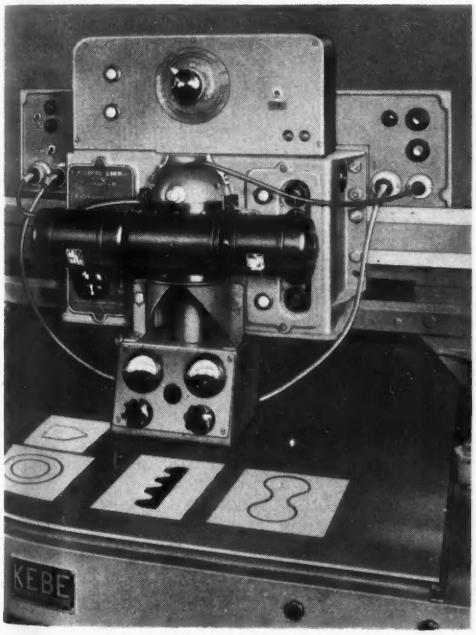


Fig. 4

device for fully automatic cutting from drawings by means of a photo-electric unit. A mechanically advanced light spot of about twice pinhead size automatically moves along the lines of the drawing in such a manner that the centre of the light spot is always exactly situated on the inner or outer edge of the line thickness, which must be about 3/32 inch. This operation is achieved by means of a special electronic device consisting of photo-cells and grid-controlled valves. The drawings must be finished in Indian ink, but good prints may also be used; paper, cardboard, plastic, or thin metal sheet templates, may also be used, as long as there is a good colour contrast between the template and its background. The machine also incorporates an electronic unit to regulate the cutting speed. Fig. 4 illustrates the gear box of this machine with the photo-electric tracing equipment.

The pipe cutter manufactured by EDUARD WILLE, Wuppertal-Cronenberg, can produce absolutely clean and square cuts, even if the cross-section of the tube is irregular. Sand-moulded or centrifugally cast pipes, thick-walled steel pipes, as well as alloyed heat-resistant pipes, can be cut with equal ease. The pipe cutter can also be employed to scarf edges in preparation for welding. It consists mainly of a stationary part, which fastens the cutter firmly to the pipe by means of four self-centering jaws, and a rotating part carrying two parting tools. On rotation of this part, tool bits having differently shaped cutting edges are automatically

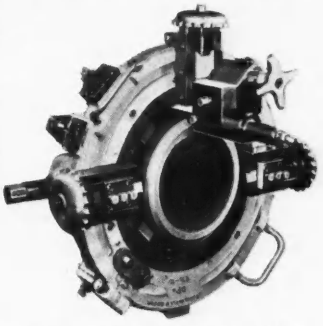


Fig. 5

fed into the stock. A copying attachment is also provided for bevelling-off the edges of the pipes prior to welding. Interchangeable templates to produce different types of joints can be supplied. The device is available in either hand-operated or motor-driven form.

STANDARD LIMITS AND FITS

(*Continued from page* 141)

Holes *A* to *G* are oversize; hole *H* is a unilateral hole with its smallest possible size as nominal; hole *J* is symmetrically disposed about nominal, while holes *K* to *Z* are oversize. Shafts *a* to *g* are undersize; shaft *h* is unilateral with its largest possible size as nominal. Shaft *j* is symmetrically disposed about nominal, shaft *k* is unilateral with the smallest possible size as nominal. Shafts *m* to *z* are oversize.

It is possible by selecting suitable values from the tables, to use the hole or the shaft as the standard member. In addition, the standard member when selected can be made either unilateral (*H* hole or *h* shaft) or bilateral (*J* hole or *j* shaft).

The majority of engineering organisations operate on a unilateral hole basis system and this automatically fixed *H* hole as the standard member. It is rare to find any of the other 20 holes in use in ordinary engineering practice.

If a nominal hole is assumed, the small letter in the letter-number combination for the shaft signifies the minimum interference in the case of shafts *a* to *g*, and the minimum clearance in the case of shafts *m* to *z*. These values of minimum interference or clearance were selected with the intention of identifying a certain letter with a certain type of fit, and it is for this reason that the change in the disposition of the tolerance boundary with size is not uniform throughout the whole range of sizes covered by the tables.

To the letter symbol, which signifies disposition of one boundary of the tolerance zone, must be added a quality factor which will fix the size of the tolerance zone and therefore fix the other boundary. For this

(*Concluded on page* 170)

SELOC

It pr… a… it seals as it locks

By moulding a metal type "Star" washer within a rubber sheath Dowty's have extended the application of an already proven locking medium.
Surface scores are protected from corrosion. The 'Seloc' also effectively prevents leakage of liquids or gases under low or medium pressures and the ingress of dirt, dust or moisture.

THE *Leakproof* LOCK WASHER *by*

DOWTY

DOWTY SEALS LIMITED · CHELTENHAM

BRITISH INDUSTRIES FAIR, 1952

We continue below the description of displays at the B.I.F., thus carrying the message of Exhibitors to our Readers who have not visited the Fair.
The importance of the B.I.F. as show-window of British Industry to the World is very great. It is hoped, therefore, that firms who have left the Fair with the feeling that expense and effort was hardly worthwhile, will be rewarded with orders which so often mature months, in some cases years, after the closing of the Fair. It is also hoped that the plea made by Mr. S. F. Burman, chairman of the B.I.F. Management Committee, for greater incentives from the Government for Exporters will not remain without response. Such incentives—said Mr. Burman—coupled with the patriotic drive now being made by manufacturers, would cure the balance of payments problem in 12 to 18 months.

George Angus & Co. Ltd. have exhibited Machine-cut Gearing, Transmission Belting, Brake and Clutch Linings, Oil Seals, Oil and Heat Resisting Mouldings, Hydraulic Leathers and Packings. The Exhibits also included a range of Rubber and Asbestos Products, Fire Hoses and Protective Clothing.

The exhibits of **B. B. Chemical Ltd.** consisted of a large variety of Bostic products. Bostic industrial adhesives and sealing compounds, used extensively in the aircraft, motor-car, shipbuilding, radio and other industries, were shown and demonstrated.

The Small Tools Division of **B.S.A. Tools Ltd.** exhibited a wide range of small tools, including Twist Drills, Centre Drills, Reamers, Broaches, Milling Cutters, B.S.A. Sintox Ceramic Tipped Tools, Cast Cutters, Quick Change Chucks and Metal Slitting Saws. Machine Vices and Oil and Suds Pumps have also been on show.

Benrath Machine Tools Ltd. were represented with an exhibition of their Static and Dynamic Testing Machines, Jigs, Tools and Gauges.

The British Electrical Development Association demonstrated some of the most recent applications of Electricity in Industry. Their Enquiry Bureau dealt with all matters pertaining to the supply and application of Electricity in industry.

British Manufactured Bearings Co. Ltd. has shown a range of Miniature Ball Bearings from 1 mm bore diameter. Precision Steel and Jewel Balls from ·006″ diameter to a tolerance of ± ·000025″ for sphericity and diameter with typical applications have been exhibited.

British Moulded Products Ltd. have exhibited Thermosetting, Thermoplastic and Injection Mouldings. Special Emphasis was on Mouldings for the Automotive Industries. Radio cabinets in moulded plastics were also shown.

The Exhibits of **British Rolling Mills Ltd.** included Bright Steel Strip, Bright Steel Bars, Rounds, Hexagons and Sections, manufactured to all British Standard Specifications and Tests. Patented Hitenspeed High Tensile Fast Machining, High Impact Steels have also been on show.

Connolys (Blackley) Ltd. have exhibited a wide range of Electric Cables and Accessories.

The Coventry Gauge & Tool Co. Ltd. have exhibited their range of Matrix High Precision Measuring Instruments and Gauges.

The exhibits of **Dunlop Rubber Co. Ltd.** included Transmission, Vee and Conveyor Belting. The new Extron Conveyor Belting was shown the first time. General industrial rubber products, Anti-corrosion and Abrasive Resisting Linings, Ebonites and Ebonite Fittings, Pipes, Microporous Separators, Hoses, Rollers, Extrusions, Gaskets and other mechanical rubber products were exhibited. The Aviation Division exhibited flexible rubber pipes used for conveying fluids, gases, etc., and for actuation.

Dunlop Special Products Ltd. has shown a range of engineering components designed and manufactured to precision limits, including flexible power transmission couplings and anti-vibration mountings for machinery and instruments. Latex adhesives and compounds, compounded rubber and special compositions were also shown.

Ega Electric Ltd. have shown Plug-in control gears, Industrial control panels, light switch gear, non-metallic conduit tubes and fittings, whilst their associated company, **Ega Developments Ltd.** have exhibited their range of Airless Spray Guns.

The exhibits of **The Electric Construction Co. Ltd.** included Rectifiers with Transformer, Automatic Control Gear, Variable Speed Motors, Circuit Breakers and their Electronic Automatic Voltage Regulator. Electric motors, Ammeters and Voltmeters have also been on show.

Fibreglass Ltd. have demonstrated Fibreglass for structural, heat and cold insulation, and soundproofing. Porous membranes for pipe-wrapping, air filter and other products made of Fibreglass were shown.

In thirty years and more we have designed and made a lot of springs—good springs from the best materials available. Now we feel we really have springs at our finger tips, and there isn't much we don't know about them. Don't you think all that experience would be useful to you? Established 1919. *A.I.D. Approved.*

LEAVE IT TO Lewis OF REDDITCH

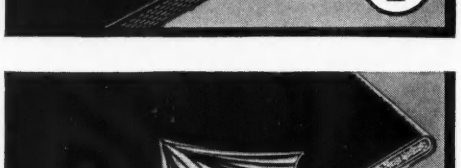
THE LEWIS SPRING CO. LTD., Resilient Works, Redditch

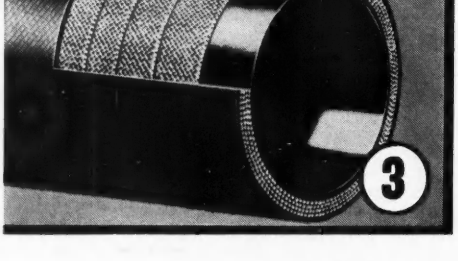
Telephone: REDDITCH 720/1/2

London Office: 321 HIGH HOLBORN, W.C.I. Phone: Holborn 7479 & 7470

BELTING AND HOSE

that can carry the load . . . and keep on carrying it





WHATEVER your needs — Transmission Belts, Conveyor Belts, Hose — take a look at the Goodyear range. Built with the accumulated knowledge of over 50 years' pioneer research and practical engineering, Goodyear Industrial Rubber Products are specifically designed for the exacting demands of present-day industry. They are stronger, more resilient and less likely to fail under abrasion, weathering and heavy loads. They give longer wear, more dependable service, and keep your operating costs to a minimum.

1 GOODYEAR CONVEYOR BELTS

The "Stacker" belt, illustrated here, is designed for installations which handle highly abrasive material and subject the belt to frequent flexing. Its tough, resilient cover " gives " under impact and resists cutting. Superior frictioning between the high-grade plies ensures that severe flexing will not cause ply separation.

2 ENDLESS CORD TRANSMISSION BELTS

Specifically built for modern high-speed, small-pulley machinery, Goodyear Endless Cord Transmission Belts incorporate a patent *balanced* construction of load-carrying cords. Their H.P. capacity is 33⅓% greater than ordinary belts of equivalent thickness; they are genuinely endless; and have an unusual degree of flexibility which gives a firm grip on small pulleys at high speeds.

3 WRAPPED PLY HOSE

This Goodyear Hose is built from high-grade rubber tube wrapped in tough rubberized fabric for greater strength. A protective cover of bruise- and abrasion-resisting rubber assures lasting wear. And scientific arrangement of the fabric plies minimizes kinking. Intended for general service this wrapped ply hose gives long life under the most arduous conditions. It is typical of the several styles of Goodyear hose built for delivery of air, water, steam, chemicals, foods, paint, solvents or petroleum products.

GOODYEAR

INDUSTRIAL RUBBER PRODUCTS

TRANSMISSION BELTING · V-BELTS · CONVEYOR BELTING · INDUSTRIAL HOSE

G.W.B. Electric Furnaces Ltd. have exhibited a range of " Autolec " steam raisers and hot water boilers which eliminate dirt and waste associated with fuel-fired boilers.

Hall, Harding Ltd. have shown modern drawing office and photoprint room equipment, drawing boards and tables, and continuous photo-copiers.

The range of versatile Oxygen Cutting Machines displayed by **Hancock & Co. (Engineers) Ltd.,** included the Hancock electronically controlled Oxygen Cutting Machine, machines for profiling, flame planing and pipe cutting as well as the newly developed " Hancomatic " profiling machine.

John Harris Tools Ltd. has shown ground thread and cut thread Taps and Dies, Screw Plug and Ring Gauges, plain Plug and Ring Gauges, Plate Gauges, and Screw Plug, Plain Plug and Ring Gauges in Wimet.

Hilger & Watts Ltd. have demonstrated Optical measuring instruments for checking gauges hobs, taps, and other precision work, and for controlling the form and dimensions of parts manufactured in quantities.

Arthur Holden & Sons Ltd. have shown Oilproof machinery paints, Cellulose laquers, Enamels and Varnishes.

John Holroyd & Co. Ltd. have exhibited Worm, Spur, Bevel and Helical Gears, totally enclosed worm reduction units and F.H.P. reduction units. The display included Super Holfos centrifugally cast phosphor bronze gear blanks and castings, and Spuncast cored and solid bars.

Geo. H. Hughes Ltd. have exhibited wheels, axles and rubber tyres for a wide variety of applications.

International Combustion Ltd. have shown Water Tube Boilers (pulverised fuel fired and stoker fired) Combustion equipment, including travelling grate and spreader, Stokers' material handling plant, Grinding, Screening and Filtering Equipment.

The Lewis Spring Co. Ltd. have exhibited a variety of Springs, Pressings, Wire Forms, Screwdrivers and Toolclips.

Ley's Malleable Castings Co. Ltd. have shown " Black Heart " malleable and " Lepaz " pearlitic malleable iron castings used for an increasing number of parts by the engineering and automotive industries.

Lion Leather Ltd. have exhibited leather beltings, flat, round and vee section, leather washers, picking bands and butts, welder's aprons, and " Leoflex " Vee Belting in open lengths. The " Quickfor " Patent Vee Belt Fasteners have also been on show.

Macrome Ltd. have displayed all types of Engineers' cutting tools treated by the Macrome process which increases their wear resistance. Various hand tools and tool kits were also shown.

Mavitta Drafting Machines Ltd. exhibited a complete range of drafting machines, fully adjustable drawing tables, a selection of mathematical scales, adjustable lamps and other drawing office equipment.

The display of **Metropolitan-Vickers Electrical Co. Ltd.** included a high-pressure rotor from a 3000 rpm three-cylinder 60-MW Metrovick steam turbine to be installed in the Chadderton Generating Station of the B.E.A.

The rotor, which weighs 3¼ tons, is carried in two bearings, and is located axially in its casing by a thrust bearing incorporated in the inlet end bearings. Steam is admitted to the high-pressure cylinder at 900 psig 900° F. After expansion through eleven high-pressure stages, the steam exhausts to the intermediate pressure cylinder at 342 psig 679° F. The high-pressure cylinder is capable of developing 12,000 hp.

The rotor is machined from a high grade carbon steel forging; the eleven discs are forged in one piece with the shaft. The stainless steel blades, of which there are 1812, are held by " T " type root fastenings to the peripheries of the discs, around which they are spaced by mild steel distance pieces. Stainless steel shrouding is fitted to the blade tips. To prevent leakage of the steam where the rotor enters the cylinder, labyrinth glands are provided. Steel sleeves secured to the shaft constitute the moving portion of the glands. Radial fins on these sleeves register, with running clearance, against spring-backed cylindrical-shaped fins of stationary packing rings housed in the cylinder casing. The high-pressure rotor is connected to the intermediate-pressure rotor by a Bibby type flexible coupling.

The oil circuit-breaker shown is rated at 66 kV, 800 amp, 1000 MVA, and embodies numerous improvements. The tension mechanism for contact lifting has a positive mechanical linkage. The tank has been designed to reduce the quantity of oil required to about 60% of that usually needed for a " dead " tank circuit-breaker of this type. Moreover, the tank handling arrangements are a considerable advance on the earlier winding method. The current transformers are arranged so that the bushings can be removed without disturbing them. The control wiring is carried in the hollow structure instead of being accommodated, with difficulty, in conduit. The bushings are of the spring-loaded condenser bushing type. Any shock, therefore, is absorbed in the spring-loading instead of being transmitted direct to the rigid flange connection.

A 50-hp 500-rpm totally-enclosed d.c. steelworks auxiliary motor, type 10/51 MDX follows generally the tradition of Metrovick steelworks motors, but the new design embodies several marked improvements, such as more hp per frame; better commutation; lighter weight and shorter length; higher maximum safe speed; improved insulation; higher efficiency; and low armature inertia (WK^2), giving increased percentage of kW input for useful work.

An exhibit has shown the application of electronic control to the take-up or let-off drive for a reel of continuous material, where the material is fed on or taken off the controlled reel by an uncontrolled motor drive. It illustrates very simply a problem frequently encountered in the textile, paper making, and many other industries, viz., the control of the speed of reels to suit the linear speed of a continuous strip of material.

The controlled reel in the model is driven by a wide-range variable-speed motor controlled by a Type ECT 50/M electronic control equipment, which employs thyratrons and a magnetic amplifier. A dancing roller is situated in a loop in the material strip between the two reels.

The 3000-hp gas turbo-electric locomotive for British Railways, of which a 10-mm scale model was shown, is the first to be built in this country and is now on trials with British Railways, Western Region. It is a six-axle loco, 66 ft. 9 in. long and weighing 130 tons. The maximum service speed is 90 mph. The gas turbine is a simple open-cycle plant in which a five-stage turbine drives the compressor and the generators. There is no heat exchanger, and a light and compact design has been achieved. The straight-through combustion system comprises six flametubes, one or more of which can be removed to give access to the inboard bearings. The nominal rating of the turbine is 3000 hp at the coupling, which is equivalent to about 2450 hp at the locomotive wheels after making deductions for transmission losses, auxiliary power requirements and unfavourable ambient temperature conditions.

The application of various instruments in the

WARDS for RAILS & SIDINGS

The above photograph shows a double-slip layout — part of a contract recently completed for the Yorkshire Generation Division, British Electricity Authority.

IN the planning and construction of railway sidings, Wards offer a high degree of technical skill and experience. Wards have been building sidings for nearly half a century and thus bring to the subject an extensive knowledge of a variety of operating conditions. Similarly, in the supply of railway equipment generally, Wards' Rail Department service covers new and re-usable rails of all normal sections, as well as switches, crossings, turnouts, buffer stops, etc. Associated supplies include colliery arches, pit props, roofing bars, floor plates and, of course, all manner of track accessories and tools. In short, Wards have a comprehensive service on every aspect of railway siding, planning, construction and maintenance for industrial operation.

The Railway Siding Consultants and Contractors

THOS W. WARD LTD

ALBION WORKS · SHEFFIELD

TELEPHONE: 26311 (22 Lines) • TELEGRAMS: "FORWARD, SHEFFIELD

LONDON OFFICE: BRETTENHAM HOUSE · LANCASTER PLACE · STRAND · W.C.2

SC/20

standard velometer range were on show. The types included: (a) The air flow indicator (for mounting directly on to the trunking or for mounting in a position remote from the actual ducting); (b) The air blast indicator; (c) The air pressure indicator; (d) The orifice and tube pattern velometer.

In addition, the pressure survey indicator and the flue gas indicating equipment have been demonstrated.

Moore & Wright (Sheffield) Ltd. have exhibited two new protractors, graduated in degrees from 0-180 and from 180-0 with a blade of 6 ins. from the working edge. They will be found most convenient for all angle measurements. Two new sets of radius gauges for the measurement of external and internal radii were also displayed. Feeler strips are now supplied in 12 ins. length with rounded ends, each in individual envelope in thicknesses of ·0015 to ·006 in ½-thousandths, and ·007 to ·025 in thousandths.

A wide range of micrometers and engineers' tools were also displayed.

The Morgan Crucible Co. Ltd. featured in the Refractories section of their stand a new refractory, Morgan M.R.1, which is rigid at 1,600° C. Another recently introduced refractory, the Morgan M.R. Plastic Mouldable, has a limiting operating temperature of 1,650° C and is suitable for most industrial furnaces. This section of the stand included the "Triangle" range of refractory bricks, combustion tubes, crucibles and pure oxide ware, manufactured by two subsidiary companies, the Douglas Firebrick Co. Ltd., Dalry, Ayrshire, and Coupe & Tidman Ltd., Treforest, Swansea. A new range of Salamander crucibles offer exceptional resistance to violent changes of temperature and give maximum resistance to erosive slags. Qualified technicians advised on the use and installation of Morgan crucible furnaces.

A most recent development, the metal-carbon contact tip, reduces the need for periodic lubrication and prevents the welding of the metal contacts in drum controllers, contactors and other types of switchgear.

Anti-friction engineering parts manufactured from "Morganite" materials demonstrated the wide variety of electrical and mechanical engineering applications of these materials. Clutch Facings made from "Morganite" sintered metal offer exceptional advantages for numerous clutch applications.

Exhibits included "Carbinert" used in heat exchanger equipment handling corrosive fluids and "Carblox" used for chemical tank linings and for blast furnace linings.

"Foliac" silica graphite paints, dry lubricants, jointing compounds and graphite greases have also been featured.

The range of ceramic-bonded carbon resistors, manufactured by Morganite Resistors Ltd., includes the "Megistor" which has been introduced for use in very small current circuits of radiation detection and monitoring equipment. The resistance range is 100 to 1,000,000 megohms. Potentiometers and fixed resistors were also exhibited.

C. A. Norgren Ltd. have demonstrated their Oil-Fog Lubricator for efficient lubrication of pneumatic equipment.

The Ozalid Co. Ltd. have demonstrated the Ozalid plan copying process with the latest Ozaprinter machines which give automatic exposure and dry development in one compact unit.

Partridge Wilson & Co. Ltd. have shown Rectifying and Transforming equipment for all power applications. Mercury Arc Rectifiers, Hot Cathode and Selenium Units were shown. The exhibits included commercial battery chargers for car, traction and stationary batteries, handlamps, testers and cellar pumps.

Payne & Griffiths Ltd. have displayed a wide range of Pressure Gauges, including Vacuum, Combined, High Pressure, Refrigeration and other special purpose gauges, together with cocks, syphons, valves and other fittings.

Pegson Ltd. have exhibited Centrifugal Self-priming Pumps.

Permali Ltd. have displayed parts and components fabricated from "Permali" and Bakelised paper. They included electrical insulation components for Switchgear, Machines and Transformers, Overhead Line Fittings, Insulating Railway Fishplates, Bearings and Silent Gears, Coal cleaning plant accessories and parts for textile machinery.

Rapid Magnetic Machines Ltd., Birmingham, have again exhibited their wide range of products, the end use of which is either Separation, Transmission or Magnetic Transportation.

This year's show had a special emphasis on their new range of permanent magnetic chutes and plate type separators.

Designed to give maximum magnetic strength coupled with simple installation, the separators are available for wet or dry processes.

Three magnet strengths are obtainable to ensure the correct application, and working faces are available with either flush or stepped poles. Requiring no electric current they operate without cost and maintenance is reduced to a minimum. The new self cleaning drum separator has also been shown, as was Electro and Permanent Magnetic Pulley type Separators.

The Rapid "Magna Hump" and "Magna Trap" for inclusion in gravity, pneumatic or hydraulic ducts, pipe lines, etc., where liquid, semi-liquid or dry fibrous products are being conveyed, and tramp iron in any form is encountered, were exhibited.

Electro magnetic separators including two for swarf separation in operation, and a new type of vibratory chute for treating fine powders that require mechanical motion to precipitate their flow, were shown.

Rapid totally enclosed electro magnetic disc type clutch.

Electro magnetic clutches and brakes for power transmission or arrestation; electro lifting magnets and feebly magnetic ore separators have also been included.

Rubber Bonders Ltd. have shown vibration and noise dampening devices, flexible couplings, rubber bonded to metal parts.

Runbaken Electrical Products have exhibited Electrical testing equipment and accessories and Battery charging equipment.

Geo. Salter & Co. Ltd. have displayed a representative selection from their range of Roller Bearings and Springs. Weighing machines for industrial applications were included in the exhibits.

Sundstrand Sanders Ltd. have shown High Speed Reciprocating Portable Sanders.

Standard Telephones and Cables Limited exhibited Remote Control Equipment to illustrate the application of the "Standard" Common Diagram system to electricity distribution control with particular

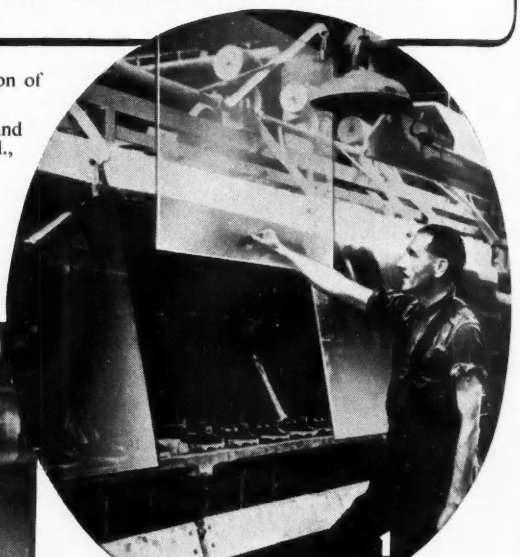
(*Continued on page* 168)

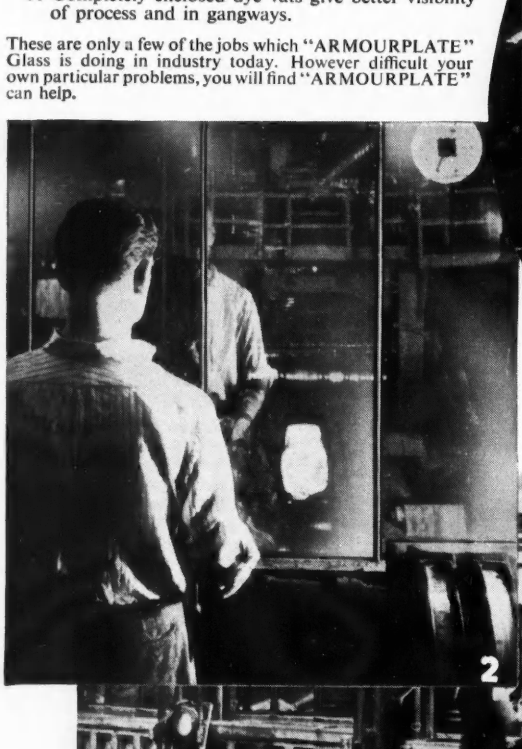
"ARMOURPLATE" GLASS

does all this—and a lot more too!

1. Frameless shields on rayon spinner ease supervision of the process.
2. Operator's shield gives protection from heat and flying scale. (Photo: Stewarts and Lloyds Ltd., Corby.)
3. Completely enclosed dye vats give better visibility of process and in gangways.

These are only a few of the jobs which "ARMOURPLATE" Glass is doing in industry today. However difficult your own particular problems, you will find "ARMOURPLATE" can help.





Write for information to the Technical Sales and Service Department.

PILKINGTON BROTHERS LIMITED

Head Office and Works, St. Helens, Lancs. Telephone: St. Helens 4001. London Office and Showrooms, Selwyn House, Cleveland Row, St. James's, London, S.W.1. Telephone: Whitehall 5672-6.

Supplies are available through the usual trade channels. "ARMOURPLATE" is the registered trade mark of Pilkington Brothers Limited

NEWS OF THE MONTH

PERSONAL

Mr. Frank Burgess, technical director of Whites-Nunan Ltd., Church Street, Pendleton, Manchester 6, has been appointed managing director of the Company, in succession to the late **Mr. Reginald Parkes.**

Mr. G. S. Causon and **Mr. A. E. Nicol,** who have been in the employ of the Hackbridge and Hewittic Electric Co. Ltd. for nearly 25 years, have been appointed directors of the Company.

Mr. P. G. Crabbe, F.R.Ae.S., M.I.P.E., a director of the Gloster Aircraft Co. Ltd., Hucclecote, Gloucester, has been appointed managing director of the Company.

Mr. John Creek has been appointed general sales manager of Fibreglass Ltd., Ravenhead, St. Helens, Lancashire.

Mr. G. H. Dowty, F.R.Ae.S., chairman and managing director of Dowty Equipment Ltd., Cheltenham, has been elected President of the Royal Aeronautical Society.

Viscount Weir of Eastwood, P.C., G.C.B., D.L., chairman of G. and J. Weir Ltd., Glasgow, has been elected honorary President, and **Mr. A. G. Stewart,** chairman and managing director of Stewarts & Lloyds Ltd., Glasgow, President, of the British Employers' Confederation.

Mr. H. S. Gibson, C.B.E., M.A., M.I.Mech.E., F.Inst.P., managing director of the Iraq Petroleum Co. Ltd., 214 Oxford Street, London, W.1, has been elected President of the Institute of Petroleum, 26 Portland Place, London, W.1. **Mr. H. Hyams, F.Inst.P., Mr. H. E. F. Pracy, B.A., M.I.Chem.E., F.Inst.P.,** and **Mr. R. B. Southall, F.Inst.P.,** have been elected vice-presidents.

Mr. Andrew Hopper has been appointed managing director of the Parsons Marine Steam Turbine Co. Ltd., in succession to the late **Mr. W. H. Pilmour.**

Mr. C. F. Joy, A.F.R.Ae.S., has been appointed deputy chief designer, **Mr. G. H. Lee, A.R.C.Sc., B.Sc., D.I.C., F.R.Ae.S.,** assistant chief designer (aerodynamics), **Mr. R. H. Sandifer, F.R.Ae.S.,** assistant chief designer (structures), **Mr. C. O. Vernon, A.F.R.Ae.S.,** chief aerodynamicist, **Mr. F. Tyson, B.A., A.F.R.Ae.S.,** chief stressman, and **Mr. K. C. Pratt, A.M.I.Mech.E., A.F.R.Ae.S.,** development and test engineer, of Handley Page Ltd., London, N.W.2.

Mr. N. G. Lancaster, M.B.E., assistant managing director of Tube Investments Ltd., The Adelphi, London, W.C.2, has been appointed executive deputy chairman of the Group's aluminium subsidiary companies: TI Aluminium Ltd., Reynolds Light Alloys Ltd., Reynolds Rolling Mills Ltd., and the South Wales Aluminium Co. Ltd. **Mr. W. H. Bowman** and **Mr. J. H. Catling,** joint managing directors of Reynolds Rolling Mills Ltd., Reynolds Light Alloys Ltd., and the South Wales Aluminium Co. Ltd., have been appointed joint managing directors of TI Aluminium Ltd.

Following the retirement of **Lt.-Col. K. G. Maxwell, M.C., Assoc.M.C.T., M.I.E.E.,** from executive duties, after 41 years' service, **Mr. E. E. Walker, A.M.I.E.E.,** has been appointed manager of the Publicity Department of Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17.

Dr. Paul D. Merica, executive vice-president, was elected President of The International Nickel Company of Canada Limited. **Dr. John F. Thompson,** Chairman of the Board and retiring President, continues as Chairman and Chief Officer of the Company. **R. Leslie Beattie,** vice-president and general manager of the company's Canadian operations, who is moving his headquarters from Copper Cliff, Ont., to Toronto, has been elected a member of the Executive Committee of the Board. **H. C. F. Mockridge, Q.C.,** of Toronto, was also elected to the Executive Committee of the Board. **J. R. Gordon,** assistant vice-president, has been appointed to the further post of assistant general manager, and in these capacities will manage all activities in the Canadian operations under the direction of Mr. Beattie. **William F. Kennedy** has been named Secretary of the Company, succeeding **Henry S. Wingate,** who will devote his full time as vice-president and a director of the company.

Mr. M. J. Noone, chief engineer of Whessoe Ltd., Darlington, has been appointed to the newly created position of manager of operations of the Company.

Sir Harry Railing, M.I.E.E., has been elected President of the British Electrical and Allied Manufacturers' Association, 36-38 Kingsway, London, W.C.2. **Mr. T. F. Lister** has been re-elected chairman and **Mr. D. D. Walker, M.A., M.I.E.E.,** has been elected vice-chairman. **Mr. James Oldroyd, T.D., M.A., A.C.I.S.,** has been appointed secretary.

Mr. Henry Spurrier, M.I.Mech.E., M.I.P.E., has been elected President of the Society of Motor Manufacturers and Traders, 148 Piccadilly, London, W.1, in succession to **Mr. G. E. Beharrell,** who now becomes deputy president.

Mr. J. H. Wiersum, A.M.I.E.E., has been appointed manager of the office of Metropolitan-Vickers Electrical Export Co. Ltd., at The Hague, Holland.

Mr. C. Wright has been appointed works manager of Francis W. Birkett & Sons Ltd., Cleckheaton, Yorkshire.

BUSINESS NOTES

George Ellison Ltd. announce that their Scottish Area Sales Office has moved to larger and more convenient premises. The new address is 7 Woodlands Terrace, Glasgow, C.3. Tel. No. Douglas 5335. Telegraphic Address INDUCTION, Glasgow, C.3

Macrome Ltd. announce with deep regret the sudden and untimely death of their Scottish technical representative, Mr. James Mackie, A.M.I.Mech.E. Until the appointment of a successor, the Scottish office at 249 St. Vincent Street, Glasgow, C.2 will deal with all inquiries.

FINE MEASUREMENT IN STUDY OF PRODUCTION ENGINEERING

Until recently there was no general recognition of Production Engineering as a study in its own right, but during the last five years Technical Colleges all over the British Isles have been rapidly developing the teaching of this subject. The College of Technology, Birmingham, has been playing a leading part in this development, which is already having considerable effect on practical measures to increase productivity in manufacturing industries.

In support of theoretical instruction, active steps have been taken to provide facilities for practical work by students—particularly in the fields of machine tools, jig and tool design, and other production techniques, and in fine measurement.

The Metrology Laboratory in the Production Engineering Section is now complete. It has already received the approval of the National Physical Laboratory as a Gauge Testing Centre, which also extends for the same classes of work for the Aeronautical Inspection Department (Ministry of Supply).

The centre can make accurate measurements of various classes of plain and screwed plug gauges; plain and taper ring gauges; parallel and taper plain gap gauges; length, height, depth and thickness gauges; screw plug gauges; profile and angle gauges.

The Production Engineering Section will be able to undertake fine measurement work for outside organisations, particularly for small engineering and other concerns in need of these facilities.

BRITISH INDUSTRIES FAIR

(*Continued from page* 167)

emphasis on the problem of Sub-Area control.

A Common Diagram control desk designed to cater for twenty sub-stations with up to ten low voltage (6·6 kV) feeder breakers each, and four representative sub-stations, two of which can be controlled from the desk was shown. The desk offers full facilities for control and supervision including: Control and indication of all circuit breakers; Indication of all isolators; On demand meter readings of all vital points; Centralised alarm indications; and Transformer tap control and indication.

The transportable SenTerCel 35 kV Cable Test Equipment displayed is one of a range of eight High Voltage Cable Test Equipments rated from 3.5 to 80 kV.

The range includes trailer-mounted equipments of 35 kV and 75 kV, and 80 kV equipment on castors, and transportable equipments of which the one displayed is typical.

All these equipments are normally used with a Fault Localising Bridge, an example of which was also shown.

A bank of capacitors totalling 150 kVAr, 400 V. 3-phase equipped for all automatic correction, was used as part of a demonstration to indicate, by means of meters and a display panel, the improvements which can be obtained from the use of shunt capacitors on industrial distribution systems. The demonstration was designed on a base load of 100 kW and indicated directly the reduction in kVA and the improvements of power factor obtained by inserting various values of capacity over a range of initial power factors. The resulting reduction in tariff charges could be easily deduced. The same display also demonstrated the way in which auto-correction functions to obtain the maximum improvement.

"Work this machine faster — she's Automatically Lubricated"

Faster working! That means increased production . . . greater . . . much greater output. You *could* get the same results, of course, by working longer hours — but that puts up your costs. No, the solution is to install Tecalemit Centralised Lubrication — fully automatic, semi-automatic or manually operated — which feeds to every bearing the correct amount of oil or grease at the correct intervals of time. Machines can then be worked faster with complete safety; no overheating . . . no breakdowns due to faulty lubrication . . . just smooth, untroubled running!

TECALEMIT
The Authority on Lubrication
PLYMOUTH & BRENTFORD

A Tecalemit Engineer is available to 'talk lubrication' with you at any time.

T325

A novel feature of the capacitors is the built-in control unit comprising air break contactor, isolator, fuses, control switches and indicating lights. This makes each capacitor self-contained with practically no increase in overall size and results in greatly simplified installation with a further advantage that only one size of contactor is used for any size of capacitor bank. Extreme flexibility of adjustment of the size of switching steps is thereby provided.

This exhibit includes a selection of telescope samples and cross-section wafer samples of all voltages of power cables manufactured by the Company, and Styrene Joints.

The Styrene Joints exhibited were a 3-core 11 kV joint and a 33 kV 3-core " H " type joint. This latter type has now been installed in many parts of the world in considerable numbers and has exemplary operating records. So far as is known this joint is smaller than any other 33 kV joint and is, in addition, a complete barrier joint.

A selection of samples from the wide range of rubber and plastic insulated cables manufactured by " Standard " was also displayed.

Tenaplas (Sales) Ltd. have shown standard Tenaplas extrusions, and the latest developments in both P.V.C. and Polythene. Multi-coloured P.V.C. covering of Copper Wire, offering an obvious increase in the range of identification colours ; the Tenaplas method of covering rods and tubes with extruded P.V.C. tubing by a chemical process, and Polythene tubing, ideally suited for plumbing, have been exhibited.

Tufnol Ltd. have displayed Tufnol synthetic laminate in form of sheets, tubes, bars, rods, angles and channels. The Exhibits included machined and moulded components for a large variety of applications.

Vokes Ltd. have shown Air, Oil, Fuel, Compressed Air, Air Conditioning and Test Bed Filters, with an efficiency rating of 99·9 per cent of all dangerous particle sizes. The new Constant Support Hanger shown was designed for supporting power piping subjected to high temperatures. The display included a Dust Recovery Filter Unit, Exhaust Manifolds and Silencers, Intake Filter Silencers and a Submicron Filter Unit.

Thos. W. Ward Ltd. have displayed photographs and descriptive literature concerning the T.W.W. Group's activities. They embrace iron and steel production, shipbreaking, scrap production, general, mechanical, electrical and civil engineering, and the manufacture of woodworking and sheetmetal working machinery.

The Zinc Alloy Rust-Proofing Co. Ltd. has provided technical information on the Sherardizing Process. Specimens of engineering, architectural, electrical and domestic ironwork rust-proofed by this process were displayed.

SILVER JUBILEE OF BIRLEC LIMITED

Birlec Limited invited the Press to visit their offices and works on May 7th on the occasion of the 25th Anniversary of the Company. At the following Press Luncheon Mr. J. H. Crossley, B.Sc., Wh.Ex., Sales Director, gave a brief review of the Company's proud history. The following is an abstract from Mr. Crossley's speech.

" We claim to be the largest organisation of our kind in the world making furnaces and allied equipment only : not motor cars nor biscuits nor anything else that is mass produced, but primarily tailor-made equipment. We are, by manufacturing process, a general engineering works still depending largely on the personal skill of the fitter and the electrician, the welder, the plater and the bricklayer—after, of course, the designer, the technician and even the salesman have played their parts.

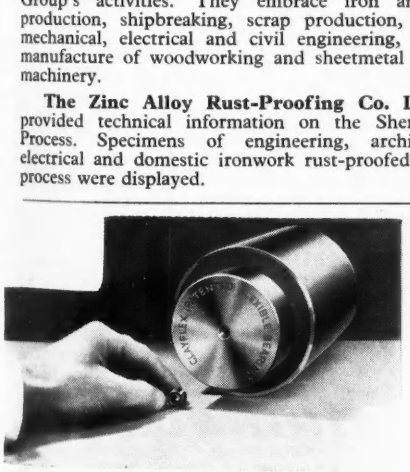
Birmingham Electric Furnaces Limited (as we were known until just after the war) was started as a new outlet for nickel alloys ; we were then part of Henry Wiggin & Co. Ltd.—and still to-day are sister firms with this Company within the Mond Nickel and International Nickel organisations. The outlet for nickel alloys which we explored lay in the manufacture of industrial electric furnaces and we grew up, it might be said, with one chief aim in view—the provision of equipment to ensure efficient and economical heat treatment. We have, it is true, digressed in many directions since the early days, but all the time our central and main purpose has been to provide industry with reliably engineered heat treatment furnaces. To underline the word ' reliable,' I can mention that the first furnace we sold, a quarter of a century ago, is still in daily operation.

We started, too, on the firm foundation of having a metallurgist and scientist as our chief. A. Glynne Lobley, or A.G.L. as we knew him, was well known to many of you gentlemen, as he was a prolific and authoritative contributor to many of your pages. To us, of course, A.G.L. was far more. He had a brilliant technical mind, and a character—stubborn if you like, meticulous certainly—which refused to be daunted. With that combination of qualities he solved many problems and we can count to our credit many pioneering designs which, after first appearing hopeless, were by persistence solved. I could mention many types but will confine myself to three ; the rotary drum annealing furnace—over 200 of which were produced in wartime and in which the vast majority of cartridge cases were annealed, not only in Great Britain, but throughout the Empire ; the duplex nitrider for aero-engine crankshafts and liners—a similar number of which were made—after one of our first orders had been cancelled because, in accordance with the best German industrial opinion, our design would never work ; and thirdly, our malleable annealing equipment—now spreading round the world—and, which is mercifully, I am pleased to say, a furnace used mainly for peacetime purposes.

As we have introduced completely new furnace designs, so also have we pioneered new heating applications in this country—continuous furnace copper brazing, continuous bright annealing, gas carburising, to mention but three. And, if we can be said to have specialised in any particular problems, they are doubtless the metallurgical ones involved in the application of gaseous atmospheres and the mechanical ones in designing various types of continuous conveyor equipment.

As I mentioned before, our attention has widened and we might be said to have departed in many ways from our original brief. We now, for example, make gas-fired equipment which, although using a large amount of nickel alloys, does not depend on their resistance qualities for the generation of heat. And in this connexion, it might be claimed that the successful development of electrical furnaces has stimulated gas furnace designers to greater efforts—away from their original box-of-bricks ideas.

A larger deviation has, however, been into the melting field —where electric equipment shows much the same sort of general advantages over cruder forms of firing as are apparent in heat treatment applications. Here, on the whole, we have followed the best practices of American design and our main types of melting furnaces are, in fact, based on those of our American associates. We started with the indirect arc unit ; just before the war we installed our first direct arc type—on six weeks delivery ! ; latterly, in collaboration with the Ajax-Northrup people, we have built high frequency induction units for steel and also low frequency induction units for aluminium and other non-ferrous alloys.



HOWARD CLAYTON-WRIGHT LTD
Wellesbourne Warwickshire
'Phone : Wellesbourne 316/7/8.

CLAYFLEX
PATENTED
FLEXIBLE BEARINGS

VIBRATION ABSORBED

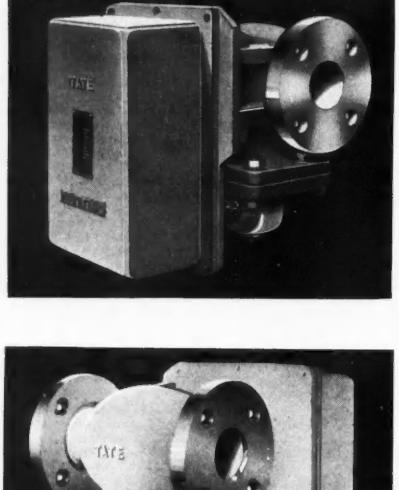
NO LUBRICATION
REQUIRE NO ATTENTION AFTER FITTING

Clayflex (pat.) Flexible Bearings are specially designed to deal with shaft deflections (parallel and angular) and to absorb vibration. Suitable to loads from 10/30,000 lbs. A brochure showing the applications and sizes will be sent on request.

AS USED THE WORLD OVER

TATE

SOLENOID OPERATED SEMI-BALANCED DC VALVES AC



For use on

STEAM, WATER, AIR, GAS, SPIRITS, OIL, CHEMICALS, ETC.

SIZES: ¼", ⅜", 1", 1¼", 2", 3", & 4"

Pressure Range: 5 lbs □" to 200 lbs □"

JONES, TATE & CO. LTD.

VICTORY WORKS

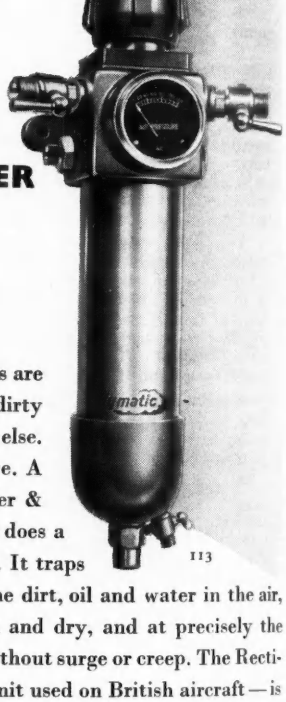
BRADFORD

'PHONE: 28348/9 'GRAMS: VALVE.

HERE IS THE

CLEAN, DRY AIR

YOU NEED FOR QUICKER AND BETTER PAINT SPRAYING



More spray-paint jobs are spoilt by wet, oily or dirty air than by anything else. But here is the cure. A Hymatic Air Rectifier & Reducing Valve Unit does a first-class double job. It traps and holds back all the dirt, oil and water in the air, and delivers it clean and dry, and at precisely the pressure you select, without surge or creep. The Rectifier — based on the unit used on British aircraft — is 40% higher in efficiency than ordinary types. The Reducing Valve is of advanced design, very sensitive and perfectly stable. Once set it holds the pressure dead steady, up to a maximum flow of 25 cu. ft. per minute — enough for three average-sized industrial spray guns.

SHORT SPECIFICATION

All-metal construction, internally treated against corrosion, castings finished in Hymatic blue. Inlet pressure up to 200 p.s.i. complete with all air connections, and drilled for flange mounting. Price £7.13.3.

Hymatic

AIR RECTIFIER-REDUCING VALVE UNIT

Send postcard for leaflet HEC 492/56

THE HYMATIC ENGINEERING CO. LTD., REDDITCH, WORCS.

Induction melting, of course, will remind some of you of our part in providing induction heat treatment equipment—which some people hopefully consider to be the future answer to all heat treatment problems.

All in all we have built and can build a type of electric furnace for every heat treatment and melting process.

Birlec interest extends to even wider fields. Two of these are simple developments of heat-treatment furnaces—pottery and cremation.

Last of all in our manufacturing interests, I come to deal with the Birlec-Lectrodryers. Although this type of equipment is now of special application to the chemical and general engineering industries, it is interesting to record that dryers originated as a metallurgical application—to dry the atmosphere in a bright annealing furnace. Since then the potential demand for these dryers has widened so much as to appear insatiable, and includes tablet packing, chocolate and sweet handling, chemical processing, general engineering with all its uses of compressed air, electrical manufacture and anywhere, in fact, where water, quite literally, can gum up the works.

I do not want to complete this review without mentioning a topic of great current moment—export. Foreign business has, for Birlec, a special significance and, for this, I must take you back to the early 1930's when, like other firms, we felt the keen draughts of national depression; nobody wanted capital goods and we were faced with the day-to-day threat of shutting shop. We were saved by one large export order; where from it might not be politic to mention, but I can perhaps give you a pointer by surmising that even to-day, those Birlec furnaces may still be annealing one side of the Iron Curtain.

Since this order, we have never looked back and have always attempted to spread our products throughout the world. This policy is now earning us hard and other currencies and, of course, the indirect impact of our furnaces and dryers on the export market can never be estimated—I for one, would not mind just 1/100th of 1 per cent of the 'export only' pottery that has been fired in Birlec kilns.

Finally I would like to touch on the personal side of Birlec. Although we employ nearly 800 people, we are still a firm of individuals as it is on individual skills that our products depend; and, by the evidence of long service, our people seem to like working with Birlec. We are fortunate, indeed, in belonging to a much larger industrial organisation and are thus able to afford recreational and other facilities which might not otherwise be possible for us.

We are now fully twenty-five years old. We are still a young firm—still a first generation firm. We have our eye to the future—and, if you remember that there is hardly a single end-product in the metal trades that does not depend at several stages on efficient melting and heat-treatment processes, we are not despondent."

The first payroll of the company contained the names of A. Glynne Lobley, until his death in January 1950 the head of the firm; George P. Tinker and T. G. Tanner, now managing and technical directors respectively, and E. Rawes, now secretary to the company.

An illustrated booklet to commemorate the occasion has been designed and published by the Publicity Department of Birlec Ltd., in co-operation with Sandbrook, Metcalf & Co., Ltd.

BRITISH STANDARDS

(Copies of British Standards may be obtained from the British Standards Institution, 24, Victoria Street, London, S.W.1)

Methods for the Sampling of Ferrous Metals and Metallurgical Materials for Analysis, Part 1. Iron and Steel. B.S. 1837 : 1952 is intended for use in conjunction with B.S. 1121 "Methods for the analysis of iron and steel" and those specifications which include clauses governing chemical composition and sampling.

Section 1 sets out the general requirements, Section 2 deals with liquid iron and liquid steel, Section 3 covers the sampling of pig, cast and wrought iron, and Section 4 includes the sampling of steel in the form of ingots, castings, blooms, billets, slabs, heavy sections, plates, light sections, bars, rods, wire, sheet, strip and tubes.

The methods are those which have been found most satisfactory in practice. As is the purpose of the methods of analysis specified in the various parts of B.S. 1121, the standard is primarily intended for referee purposes and should be considered as a guide to sound sampling procedure rather than as a rigid specification. Price 2/6.

STANDARD LIMITS AND FITS

(Concluded from page 164)

purpose, the I.S.O. system provides 16 grades of quality, referred to as the 16 fundamental tolerances. The finest quality is number 1, numbers 5 to 8 represent good-quality machining, while quality 16 is so coarse that it provides more than sufficient tolerance for non-machining processes such as die-castings.

The Standard also recommends that the basic sizes for mating parts should be selected as far as practicable from the standard series of preferred basic sizes, tables of which are given.

A draft of the new system has now been published and has been sent out to engineering firms to allow them to study the new proposals and report their comments to B.S.I., who will summarise and tabulate all data received and transmit them to the committee concerned with the revision.

LATEST INDUSTRIAL LITERATURE

1. Precious Metal for Industry. 22-page booklet describes services and products in precious metals for employment in the shipbuilding, electrical and engineering industries. Products specified include a wide range of solders and brazing alloys, fluxes, electrical contacts, precious metal wires, gold and silver anodes, silver strip, gold and silver salts and grain silver.

2. Two-colour Prints from One Tracing. Folder describes the principle of a new process by which for the first time dyeline prints in two distinct contrasting colours can be obtained. The process provides a unique and simple means of giving the clearest visual differentiation on a photoprint between any two parts of the original drawing where such clear distinction is required.

3. Plastics for Industry. Profoundly illustrated brochure deals with industrial applications of plastics parts manufactured by compression moulding, transfer moulding, injection moulding, machining and fabricating. A Comparative Chart gives in a simplified form the main properties of a representative range of plastics to assist in the selection of the most suitable material for any specific application.

4. The Welding, Brazing and Soldering of Copper and its Alloys. Illustrated 188 pp. Handbook deals with the jointing of copper and its alloys. All the major processes and many others are described in considerable detail. Separate chapters deal with fusion welding, bronze welding, brazing and soft soldering.

5. Latest Development in Torque Control. Illustrated leaflet describes the latest fully automatic Torque Spanner of entirely new design. Of great interest to aircraft and motor manufacturers, air lines, etc., the spanner can be used by unskilled labour with precision results.

6. The Macrome Treatment. Leaflet, well produced and neatly illustrated, emphasises the advantages of using cutting tools treated by the thermo-electric process which results in increasing the toughness of tool steels without reducing their hardness.

7. 100% Protection is the title of an illustrated leaflet dealing with a plastic protective coating for the protection of tools, machined parts and simple assemblies. Advantages include the reduction of packing time by at least 60%, protection against corrosion, rust, etc., protection against abrasion during transit as well as from heat and cold.

8. Transformers for Power Distribution and Industrial Purposes. Illustrated brochure gives general and technical description of standard transformers up to 500 kVA for the usual power house, sub-station and distribution purposes. Special types, e.g., furnace transformers, auto transformers and static balancers are also offered. Specifications and the following illustrations are included:—Typical 3 Phase Core for Transformers up to 350 kVA; Coil and Core assembly of 3 Phase Oil cooled Transformers; High voltage side of 350 kVA 3 Phase transformer; 75 kVA Phase-Conversion Transformer and 72 kVA Furnace regulating Transformer with self-protecting Tap-change Switch.

9. Operating Valves. 36-page catalogue with numerous photographic illustrations and diagrams contains specifications and descriptions of a wide range of operating valves for the control of single and double acting cylinders for use on air chucks, air vices, lathes, screw machines, special machine tools, power presses, steel and tube mill equipment, welding, forging, diecasting and polishing machines and other air actuated equipment. Models described include hand, foot, mechanical and solenoid controlled types.

10. Hypocycloidal Speed Reducers. Exceptionally well designed and produced brochure deals with the development and technical details of a range of speed reducers which make it possible to provide any reduction required between 3 : 1 and 100,000 : 1. The approximate horse power range is from 1/16 to about 25. Applications include conveyors, food machinery, electrical switchgear, radar, hoists, pumping machinery, mining machinery, mixer drums, drying ovens, textile and printing machinery, etc.

MAIL THIS COUPON TODAY

THE ENGINEERS' DIGEST, 5.52
120, Wigmore Street, London, W.1.

Date.....

Please send free and without obligation the literature indicated by the following circled numbers :

1 2 3 4 5 6 7 8 9 10

Name .....

Position .....

Company.....

Address .....

Classified Advertisements.

The rate for all classified advertisements is 6d. per word; in bold print 9d. per word; minimum order 6s. Box number advertisements 1s. extra. Instructions together with remittance must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

SITUATIONS VACANT

GIRLING LIMITED
CHASSIS ENGINEERS

This expanding concern can still absorb suitable candidates into their engineering departments.

DRAUGHTSMEN for Design and Detail. Shop experience a decided advantage.

DRAUGHTSMEN. Juniors, for Production Drawing Office. Experience on mechanical details for mass production is desirable.

DRAUGHTSMEN, Senior, with Higher National Certificate or equivalent and first-class drawing-office experience, Apprenticeship or works experience preferable.

RESEARCH ASSISTANT of degree or certificate standard.

SENIOR RESEARCH ASSISTANT of degree standard. Design and experimental experience essential.

Applications, by letter or in person, will be welcomed at the

PERSONNEL DEPARTMENT
GIRLING LIMITED
King's Road, Tyseley, Birmingham 11.

ENGINEERING DRAUGHTSMEN. The British Drug Houses, Ltd., require qualified Engineering Draughtsmen for the light chemical industry. The work includes the design and modifications of special machines and vessels, plant and pipework layouts. Previous chemical plant experience desirable but not essential. Technical training to at least Ordinary National Certificate standard. Five-day week. Pension scheme and sports club.—Apply in writing, stating age, qualifications, experience and salary required, to **Staff Manager,** Graham Street, City Road, N.1. J945.

SENIOR AND JUNIOR TECHNICAL ASSISTANTS are required for experimental and development work on aircraft propulsion units. Candidates should have an Engineering Degree or its equivalent. Previous experience of this type of work is desirable but not essential. Reply giving details of qualifications and experience to Reference SA. 2a, **Armstrong Siddeley Motors,** Coventry.

A YOUNG THIRD ENGINEER required by leading Company for large Palm Oil Factory in Malaya. Essential qualifications are B.O.T. 1st Class Marine Certificates in Steam and Diesel. Single preferred. Prospect of further promotion for a good man. Starting terms equivalent to £1,200 rising to £1,330 plus free accommodation, passages, transport allowance, commission on profits, and other benefits. Write with details to Box M. 3574, **John Haddon & Co. Ltd.,** Salisbury Square, London, E.C.4.

A SUBSIDIARY, situated in the London area, of a large engineering company requires the services of a **competent planning engineer** with experience in the manufacture of mechanical and electrical engineering products. Rate fixing and time study an advantage. Write stating education, experience and salary required to Box No. "AHF.5."

JOSEPH LUCAS LTD. have vacancies in their design drawing office for several first-class Mechanical Designers for work on small motors and switch gear. Applicants should be up to H.N.C. standard and it is desirable that they should have experience in designing for quantity production. The positions are permanent and pensionable and offer excellent opportunities for men possessing initiative and originality. Please reply, stating experience, qualifications and age, to **Personnel Manager, Joseph Lucas Limited,** Great King Street, Birmingham.

WORK WANTED

BOTTLENECK IN CASTINGS ? We can probably help you. Small part of our capacity available at the moment for precision, aluminium gravity die castings, zinc pressure die castings. High standard of workmanship; established 1828. Write or 'Phone **Thos. Ashworth & Co. Ltd.** (Dept. E.D.1) Vulcan Works, Burnley, Lancs. (Burnley 5259, 4 lines).

ENGINEERS MATERIALS WANTED

WANTED 1¼ IN. THICK M.S. PLATE in exchange for large quantity hex. bars (800 ft black ½ in. to 2½ in. A/F, 6 sizes, 2500 ft. B.D. $\frac{7}{16}$ in. to 2 in. A/F, 13 sizes). **F. J. Edwards Ltd.,** 359 Euston Road, London.

ELECTRIC MOTORS and POWER PRESSES FOR SALE

24 NEW BROOK FLANGE MOTORS FOR SALE, type R7, squirrel cage, 1 h.p. 1000 r.p.m. B.B., S.Prot. 400/3/50.

24 as above type R9, 750 r.p.m. **F. J. Edwards Ltd.,** 359 Euston Road, London, N.W.1. EUSton 4681.

DOUBLE ROLL FEED FOR POWER PRESS FOR SALE. Arnott-Harrison No. D20, rolls 6⅜ in. wide × 2 in. dia. of type roll feed from bolster 4⅞ in. high. Between rolls 25⅞ in. Bolster 21 in. × 13½ in. Photo etc., **F. J. Edwards Ltd.,** 359 Euston Road, London, N.W.1.

MACHINERY, ETC., FOR SALE

8 ONLY—5 Ton Worm Geared Pulley Blocks by Fellows Bros. Ltd. 20 ft. Lift Hook to Hook. Excellent Condition—certified tested. £22/10/- each. **Heeley Tool Co., Ltd.,** 34-36 Bath Street, Sheffield 1.

FULL STEAM IN FIVE MINUTES with B & A Electrode Boilers, used by British industries for 20 years. No boilerhouse, no flue, no attendant needed. The most compact and convenient steam raisers available, can go beside machines using the steam. Write for leaflet 127, **Bastian and Allen Ltd.,** Ferndale Terrace, Harrow, Middlesex.

RECONDITIONED EX-ARMY HUTS, and manufactured buildings. Timber, Asbestos, Nissen Type, Hall Type, etc. All sizes and prices. Write, call or telephone—**Universal Supplies (Belvedere) Ltd.,** Dept. 50, Crabtree Manorway, Belvedere, Kent. Tel.: ERITH 2948.

MISCELLANEOUS

TRANSLATIONS (Technical, Commercial), all languages. Abstracts also supplied. **Olympia Translation Service,** 149 Blythe Road, London, W.14. RIVerside 5135.

LITERARY RESEARCH. Industrial Consultants undertake literary research on all technical subjects. Sources investigated include technical publications, both English and foreign, patent specifications, etc. Write for quotation to Box No. W.E.6, "The Engineers' Digest."

WANTED.—Complete 1940 and 1941 volumes of "The Engineers' Digest" at double of original subscription price. We also wish to purchase the following Back Numbers: December, 1951, January, February and March, 1952, at 3/6 per copy.—Subscription Dept., 120, Wigmore Street, London, W.1.

INDUSTRIAL BRUSHES
(TWISTED WIRE)

TO YOUR SPECIFIC REQUIREMENTS

Twisted wire core brushes for either hand or motorised operation can be supplied promptly with fillings of :
WIRE, BRISTLE OR NYLON
also
WOOL MOPS

Your enquiries will be welcomed

Descriptive literature free on request

Parker-Hale LIMITED

Bisley Works
Tel.: CEN. 7637-8 BIRMINGHAM 4.